

# Chemical & Process Engineering

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## Topics of the Month

### Prescription for productivity

BY the yardstick of added value per employee of its products, the American heavy chemicals industry's productivity is at least three times greater than the British. This is the expert opinion of the Heavy Chemicals Productivity Team composed of 17 members of the British chemical industry drawn from all levels, which toured America last spring. Giving this view in their report, published on January 19, they make a number of important recommendations for increasing productivity in Britain. Most of them are concerned with people. The team were greatly impressed to find that the ratio of the productivity of the U.S. industry to the British was also the ratio of the proportion of technical men to employees in the two industries, *i.e.* three to one. The Americans have, on the average, one technically qualified man to every six workers, while in Britain the ratio is about one to sixteen. Therefore, the most important recommendation is that British manufacturers should immediately arrange, in co-operation with the universities and technical colleges, for the number of technical graduates in their companies to be increased as rapidly as possible, in some factories even doubled.

Another fundamental reason for American productivity is the much greater percentage of modern chemical plant and equipment than in Britain. The investment in capital equipment per employee is some two to three times that in Britain. Again, there is a significant similarity between this ratio and that of productivity in the two industries. Therefore, several of the recommendations concern plant and

equipment. For instance, every company should appoint a committee to speed up projects once they have been sanctioned and to ensure that new plant is designed for the maximum capacity of the market and for the maximum annual return per unit of capital employed.

These recommendations, and many others, are addressed to the manufacturers. To the trade unions, the team address a call for less restrictionism. They should allow non-tradesmen to become apprenticed to a trade up to the age of 35 to 40 and should substantially cut the present five-year period of apprenticeship. Also, they should co-operate more with managements to raise productivity.

To the Association of British Chemical Manufacturers the team recommend action to develop the free interchange of technical information throughout the industry, *e.g.* on plant modernisation and layout, on bulk handling and on effluents. This suggestion will be particularly welcomed by those who, like ourselves, have tried for years to obtain more information for publication from chemical manufacturers. There is too much secrecy in many firms and we would draw attention to the observation by one chemical manufacturer we know that when a door is shut, more is shut out than in.

Another sensible recommendation to the A.B.C.M. is that it should encourage co-operation between manufacturers and users on the design and standardisation of new plant and equipment. Standardisation of units is no panacea, but it can help greatly in speeding up deliveries and reducing costs.

This very brief summary of this most important report, which is 78 pages long and is available from the A.B.C.M. at 3s. post free, would not be complete if it left the impression that the Americans have outdistanced us in every respect. Indeed, by the acid test of profitability, the British industry is just as profitable as the American and a number of its chemicals are cheaper than American. But before it is concluded that, as our products are cheaper, there is, after all, little we need to do, it should be pointed out that in the past few years the percentage rise in American chemical prices has been only half that which has occurred in Britain. This is an important trend.

More emphatically to the credit of the British industry is its general superiority in joint consultation, welfare services, effluent disposal, by-product utilisation, guarding of machinery and application of work study. However, when every admissible credit is given, the stark fact remains that the American industry's productivity is thrice that of the British. This position will remain unaltered unless we have some action on the lines laid down in this thoughtful, thorough and objective report.

### Corrosion research

**A**N informative picture of the effect of climatic differences on atmospheric corrosion was given by data presented by J. C. Hudson and J. F. Stanners at a meeting of the Corrosion Group of the S.C.I. held in Nottingham on February 5. This data consists of the results of routine observations on the corrosion of small reference specimens of ingot iron or zinc exposed at atmospheric testing stations all over the world. Up to 20 separate annual tests at more than 20 sites were involved.

In Great Britain, where for most of the year the climate is sufficiently humid to promote corrosion, the determining factor for its severity is the sulphur pollution of the air. Tests made in collaboration with the Fuel Research Station at 16 sites where the atmospheric pollution is measured have shown an almost perfect correlation between the amount of sulphur dioxide taken up from the atmosphere by lead peroxide pollution gauges and the rate of corrosion both for steel and zinc.

In the absence of sulphur pollution, corrosion at the sites overseas is generally slight; in dry climates it is negligible. For example, tests at Delhi indicate that the resistance of the Delhi pillar to corrosion is to be attributed to the mildness of the corrosive conditions there rather than to any superiority of the iron itself.

Corrosion on surf beaches in the tropics may, however, be exceptionally severe. At Lighthouse Beach, Lagos, Nigeria and at Kure Beach, N.C., U.S.A., the corrosion rates for steel are about five times greater than those in the most corrosive industrial atmospheres in Great Britain. The severe corrosion at these places is associated with the salt spray from the sea and the rate of corrosion falls off rapidly with increasing distance from the surf line.

Preliminary tests on specimens exposed at different heights on the Sutton Coldfield television mast suggest that the effect of distance from the ground is secondary to the natural variations in corrosion rate from one year to another.

Some details of experimental technique were discussed. Work, in which American investigators have collaborated, has confirmed that, at low copper contents, variations of a few hundredths of 1% in copper content have a marked effect on the corrosion resistance of ingot iron. Because of the increasing difficulty in controlling the copper content of

different batches of ingot iron, the small reference specimens used in the Corrosion Committee's most recent tests have been made of copper-steel instead of ingot iron. The copper-steel now in use contains about 0.3% copper; minor deviations from this figure should not affect the corrosion rate within the experimental error. It has also been found that, although it is advisable to stir the inhibited hydrochloric acid solution (Clarke's solution) used for derusting exposed iron or steel specimens after test, failure to do so does not impair the accuracy of the results, at least for ingot iron or copper-steel.

### A century of invention

**J**UST over a century ago the Patent Law Amendment Act was passed in Britain. This was a great step forward in simplifying and making less expensive the complicated system of granting patents which had existed until then. Up to 1852 the granting of a patent involved visits to seven different offices and payment of fees up to £300. No wonder the system drew upon itself the scathing indictments of contemporary writers such as Charles Dickens who held it to ridicule in his 'Poor Man's Tale of a Patent.' Coincident with the passing of the new Act was the opening of the Great Seal Patent Office as the sole office for granting patents for inventions. This office was situated at Southampton Buildings, Chancery Lane, London, and it was at this historic address that the modern Patent Office celebrated recently the centenary of its foundation with an exhibition held in its famous library. Here one could trace the history of patent law reform and its development, from the herculean labours of the first Superintendent of Patents, Bennet Woodcroft, F.R.S., to the Patents Act of 1949.

Browsing among the many historic patent specifications on-view, we found the earliest known English patent granted in 1449 to John Utynam, a Fleming, for stained glass for the windows of the King's Chapels at Eton and Cambridge. Nearby was the first atomic energy patent, Whittle's jet propulsion patent, and a patent of 1916 for the first flying bomb. Among the chemical patents shown were a synthetic rubber patent of 1911, the provisional specification for benzene hexachloride, an early petroleum cracking patent of 1889, the complete specification (1948) for streptomycin and a polythene patent (1937).

Among the odd examples of human ingenuity was a claim by a Dr. Jaeger of Stuttgart for pills made of the hair of healthy women, the scent of which was said to be beneficial. Then there was the patent for a cure for consumption consisting of garlic roots soaked in warm brandy! Heroic medication, indeed.

In addition to these historic and curious patents, the exhibition included Patent Office circulars, a display of Letters Patent and wax seals of the past, and documents and books concerned with the staff of the Patent Office during the century. There were also some historical trade marks, notably one for *Sunlight* soap.

Like many other organisations, the Patent Office suffered badly during the war. In August 1944 a flying bomb damaged the whole of the frontage facing Staple Inn. However, the most serious loss was that of trained staff. In consequence of this, by 1947 the accumulation of specifications awaiting examinations had reached well over 30,000. During the past five years, additional staff has been recruited and trained and today the total is nearly 1,000 and the number of outstanding specifications has been reduced to 22,000.

### Super synthetic rubber

THE German firm of Bayer, Leverkusen, formerly a section of I.G. Farbenindustrie, has developed a new synthetic rubber which has drawn enthusiastic comments from American rubber chemists. According to one scientist at the American rubber manufacturing centre of Akron, Ohio, the new synthetic 'can revolutionise the entire synthetic rubber-making and -consuming industries.' Another believes that 'we do not have to look any further for a rubber that will outlast the normal life expectancy of an automobile.' The new rubber is called *Vulcollan* and it is described as having 'unbelievable' resistance to tear, abrasion and combustion. Ordinary rubbers burn easily.

However, with all these advantages, the material has one big drawback—high cost. Its price is about ten times greater than the 23 cents/lb. charged for standard American GR-S rubber. It is thought, however, that with modern American production methods the price could be cut to two or three times that of GR-S.

Details of the manufacture of *Vulcollan* have not been released, but it is thought that the basic raw materials are chemicals derived from coal tar and natural gas. Intermediates are believed to be coal tar, benzole and hydrogen. In the final process it is postulated that adipic acid is treated with ethylene glycol and the product of this reaction is treated with naphthalene di-isocyanate to give *Vulcollan*.

### Pelleted petrol

EASIER and safer stockpiling and transport of petrol and other liquid fuels has been made possible by developing the idea of solidifying petrol which produced one of the most fearful weapons of the last war, napalm or jellied petrol. A new process recently patented in America (U.S.P. 2,610,113) transforms petrol into a solid which can be stored out of doors and from which the liquid fuel can easily be recovered when desired.

Briefly the process consists of adding 5% by volume of humectant agent (glycerin) to a 2% aqueous solution of sodium alginate or sodium polyacrylate, stirring in an equal volume of petrol (or other hydrocarbon fuel) to form an emulsion, then introducing the emulsion in a rapid succession of drops into a 10% aqueous solution of calcium chloride. On contact with the calcium salt, the emulsion droplets immediately gel in the form of pellets which are of uniform size and which are insoluble in both water and petrol. The pellets are then 'aged' in an enclosed chamber equipped with a petrol vapour recovery system. After losing an initial amount of moisture and petrol vapour here, future loss is said to be quite small, and the pellets can be stored unprotected in open air. In use, the pellets burn slowly and evenly. If liquid fuel is required, nearly complete petrol recovery can be obtained simply by shredding and pressing the pellets.

The role of the humectant in this process is described as a most important one. Without it, it has been found that this type of fuel, after prolonged storage, begins to liberate water. When drying proceeds far enough, the fuel itself begins to escape, creating both loss and hazards. Glycerin, by lowering the vapour pressure and causing stronger absorption of water in the gel structure, retards drying and prevents fuel loss, regardless of atmospheric conditions. The optimum amount to be incorporated varies with the climate of the area where the fuel will be stored: 5% is suitable for average conditions; hot, dry regions may require the use of 10 to 15%.

### Indian atomic energy

CHEAP power is one of India's fundamental requirements for raising the living standard of her people. Thus it is not surprising that the Government is energetically developing atomic energy with the object of making it a source of cheap power. The instrument of this policy is the Atomic Energy Commission which was set up in 1948 with four objects: (1) to survey the country for atomic raw materials; (2) to develop them industrially; (3) to set up an atomic reactor for experimental purposes; and (4) to promote fundamental research.

Pursuit of the first object has resulted in the discovery of uranium-bearing ores in Bihar and elsewhere. The second object has been fulfilled at least partly by the formation of a Government agency, Rare Earths Ltd., at Alwaye in Travancore-Cochin. This company will process monazite, which is found in great quantities in south India. Presumably they will extract from it the radioactive metal, thorium. One of the members of the Atomic Energy Commission has stated that the monazite reserves are sufficient to supply India's entire power requirements at 100 times the present level for centuries.

So far, there is no atomic reactor in India, although Dr. K. S. Krishnan, Director of the National Physical Laboratory and a member of the Atomic Energy Commission, has stated that there is no reason why a medium-size reactor should not be built 'within two years.'

The Commission's fourth object, promotion of fundamental research, is being carried out with a number of programmes for cosmic ray investigation. This particular study has been chosen because the magnetic equator passes across Indian territory, making the country ideally situated for cosmic ray research. Furthermore, the equipment required is relatively inexpensive. The headquarters of atomic research is the Tata Institute of Fundamental Research in Bombay. Other centres are the Bose Institute in Calcutta and Delhi University. Altogether, there are 24 Government-aided research schemes in progress in various parts of the country.

### Hormone from ox glands

THE first commercial production in Britain of the anti-rheumatic drug, adrenocorticotrophic hormone (ACTH) from ox pituitary glands has been started by Crookes Laboratories Ltd. at their London factory. Crookes thus become the second British ACTH manufacturers, the other being Organon Laboratories Ltd., who extract the hormone from the more usual source, pig pituitaries. Present output of ACTH in Britain is now ample to meet all domestic needs, leaving a margin for export.

Crookes use glands from home-killed cattle. Owing to the accumulation of stocks, initial production is at the rate of 100 g./week, but it is expected that in future the supply of glands from home-killed cattle will restrict output to between 50 and 60 g./week. The yield of ACTH is about 1% of the weight of the gland. One advantage of using ox glands is that they are large enough (weighing about 1 g.) to enable dissection of the anterior lobe from the posterior. It is from the former that the ACTH is extracted. The other lobe contains unwanted substances. The pig gland (weighing about 0.2 g.) is too small for dissection and this complicates processing. However, it contains more ACTH than ox glands. Nevertheless, if all factors are considered,



production from ox glands costs about the same as from pig glands.

Crookes claim that their ACTH is about twice as potent as the international standard. Ten mg. of ordinary ACTH gives 10 International Units of the hormone. Only 5 mg. of Crookes' material is necessary for this dosage.

The production routine starts with the extraction of glands with acid-acetone. The product is precipitated with solvents to yield crude ACTH. This is adsorbed chromatographically to obtain the active hormone which is eluted from the adsorbent with acid and solvents. The product is then re-precipitated with solvent and finally dissolved and again precipitated to arrive at ACTH in powder form. Aseptic conditions are maintained throughout the process.

### Davy, Faraday and Italian oil

**B**OTH British and American oil companies have been interested for some time in Italian oil deposits, and a number of licences have been granted by the Italian government for exploring possibilities of considerable deposits. Sicily has now been added to the oil regions, estimates putting annual output as high as 10 million tons if all goes well. This figure alone exceeds Italy's annual consumption so that an export surplus is promised. The large reserves near Gela are being worked by the Mediterranean Oil Co., a subsidiary of the Gulf Oil Corporation and the McMillan Petroleum interests of America. Progress has been maintained in the largest oil wells in actual operation, that is, in the Po Valley. The Cortemaggiore centre has a well which gushed 65 ft. when tapped some months ago by the Italian Finance Minister; and it is "Super Cortemaggiore" petrol which is sold at the roadside pumps in Rome and Italian towns. Near Cremona and Rimini are other promising oil fields in which British as well as American concerns are interested.

Even more striking is the wide use of methane now piped to all northern cities of Italy and used by 80% of the Fiat works power units in Turin. The gas is bottled for portable gas-cooking units in many villages, and will save 3.5 million tons of imported coal as factories are converted from coal and electrical power.

One point forgotten in reviews of these developments is that, modern as is the Italian methane industry, the history of oil has no such classical connections as in northern Italy, for it was to this region that Davy and Faraday came on their grand tour of Europe in 1813. They came to see the flaming marsh gas at Pietra Mala. It was raining hard, records the immortal Faraday, 'yet that of course would not deter Sir Humphry from visiting these places.' To Davy all was fish that came to his net. Faraday filled a bottle with the gas and noted how it burned with a 'very pale blue flame like spirits of wine.' Davy succeeded even with his imperfect portable apparatus in exploding the gas with oxygen over mercury and noted it appeared to contain carbon and hydrogen. And then, 'in the now almost deserted laboratory of the Florentine Academy, Sir Humphry made decisive experiments.' He used 'platina' wires to form a spark gap, exploded mixtures, absorbed the carbonic acid in 'pure potassa,' and concluded that 'a light hydrocarburet, pure' was the nature of this gas which with chlorine and a spark had yielded carbon deposit on the sides of the vessel.

These investigations of two immortals of British science must add to the interest with which we in Britain will follow the fortunes of the oil and methane industry in Italy.

### Chemical prospects in America

**C**ONFIDENCE in the American chemical industry's ability to expand is the keynote of a review of 1952 and a forecast of 1953 by Charles S. Munson, President of the Manufacturing Chemists' Association, Inc., published this month in our associate journal, *Manufacturing Chemist*. According to him, the index for industrial chemical output in October reached a new record of 574 (1935-39=100), compared with 556 in 1951 and the wartime peak of 412. At the same time, prices have fallen by an average of 3½% compared with the previous year.

Thanks to its vigorous expansion policy the industry was able to overcome the material shortages of 1952. Supplies of sulphur and chlorine are back to normal and there has been a marked improvement in ammonia and benzene. However, the effect of the steel strike on benzene supplies is still being felt. The industry was even able to get some advantages from the shortages; for example, the sulphur scarcity stimulated the search for new sources and progress in conservation methods.

Chemical industry average wages rose to more than £25 per week (\$71.38), an increase of more than £1 over the previous year. Average hourly earnings in the industry, indeed, have risen by 75% since 1945. However, these rises in pay, combined with the excess profits tax, reduced the industry's profits. Thirty-three companies reported a 10% decline in net income for the first nine months of 1952 compared with the same period in 1951 when, in turn, profits were 14% less than in 1950. Munson regards these figures as serious and predicts difficulties in raising new risk capital if profits continue to decline.

Another cause for anxiety is the decline in the number of chemical and chemical engineering graduates predicted for the period up to 1955. In order to stimulate recruitment, the Manufacturing Chemists' Association has asked all its members to co-operate with educational bodies with the aim of encouraging students to train for careers in the industry. This programme is cited as evidence of the industry's confidence in its future even though production may not increase as rapidly as hitherto. 'As the top sponsor of research and development in the manufacturing field, the industry looks to a continuation in 1953 of its traditional flow of new products, new processes, and new knowledge of how to put the elements together in serviceable combinations.'

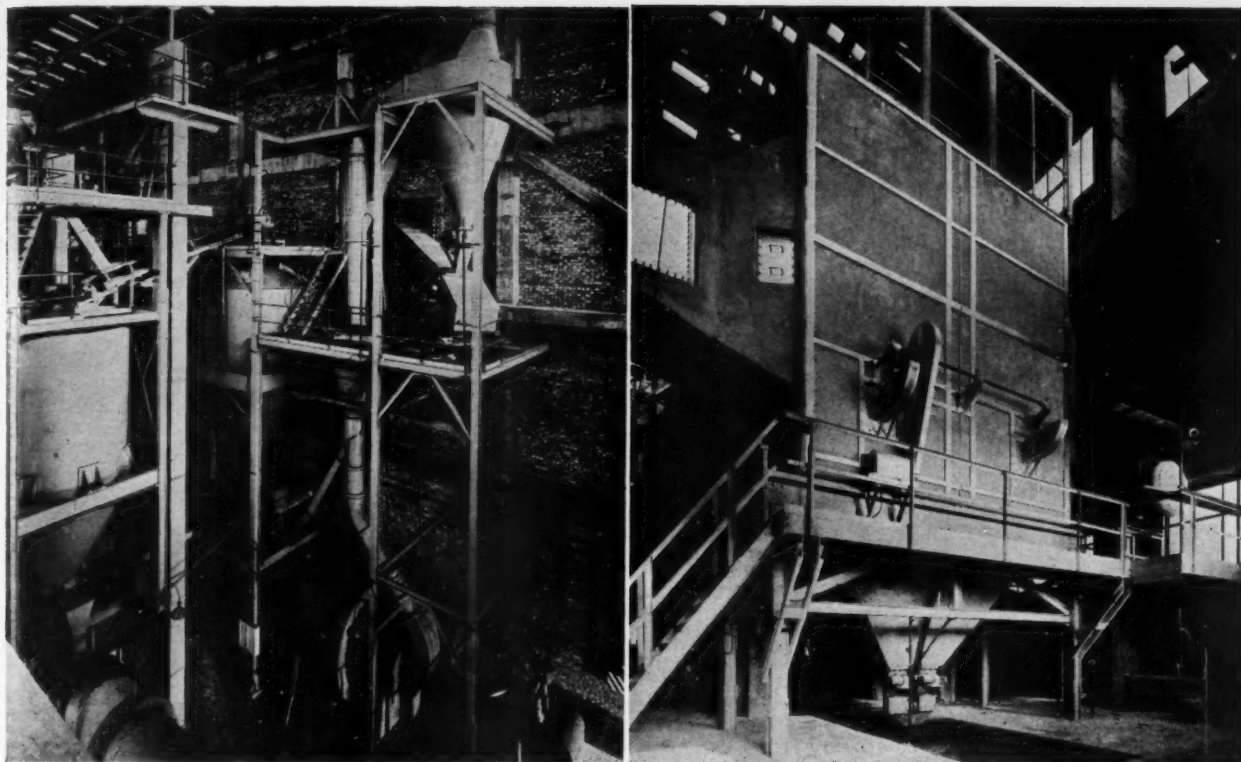
### Six-hundred-dollar idea for pump lubrication

**A** REPAIRMAN at American Cyanamid Co.'s fluid cracking catalyst plant in Fort Worth, Texas, observed that many operating failures of a screw-type pump used in the plant's process machinery were due to an inadequate arrangement for lubricating parts. Bearing this in mind, the repairman, R. B. Poteet, came up with a suggestion which eliminated the problem and increased efficiency of the pumps.

The suggestion was to drill a hole in the end of the pump's drive shaft and insert a grease fitting which would distribute grease to parts not getting sufficient lubrication. This greatly reduced wearing out of parts, cut general repair bills and sped up operation of the pumps. Known as Moyno pumps, these devices are a critical part of the cracking catalyst process machinery, pumping slurry from one place to another.

Mr. Poteet, who submitted the idea through Cyanamid's suggestion system, was awarded \$600.





(Left) Air-swept conical ball mill, feed hoppers and cyclone separator. (Right) One of the electrostatic precipitators.

## SULPHURIC ACID FROM FLASH-ROASTED PYRITES

### First British plant in operation at titanium oxide factory

The first plant in Britain for producing sulphuric acid by the flash-roasting of pyrites has been started up at the Grimsby titanium oxide factory of British Titan Products Co. Ltd. The plant has three flash roasters, two of which are now in operation. These supply sulphur dioxide to a cold  $\text{SO}_2$  oxidation plant with a capacity of 140 tons/day of 100% sulphuric acid. When finished, the third roaster will supply  $\text{SO}_2$  to the existing 120 tons/day sulphur-burning acid plant. Thus the complete project will greatly increase the factory's output of sulphuric acid while drastically reducing the demand for sulphur. The new plant, which is described below, is of particular interest as being one of the first examples of the new policy of cutting down Britain's dependence upon American sulphur.

**A**PART from ilmenite, sulphuric acid is the major raw material of the titanium industry. Indeed, the industry is the fourth largest user of sulphuric acid in the United Kingdom. Obviously, therefore, the assurance of a ready supply of acid is vital to continuous production. The pyrites roasting sulphuric acid plant, designed and built to supply the acid requirements of the Grimsby factory of British Titan Products Co. Ltd., has aroused considerable interest in the chemical engineering world. It is the first of its kind to operate in Britain and, more-

over, it offers several facilities hitherto not available in this type of plant, notably the facility to operate in conjunction with an existing sulphur-burning plant.

The time taken for construction from a bare site to full operation was just a little over one year, this being no mean achievement when it is realised that the nature of the ground demanded that the entire plant be built on piles.

The plant is intended to supply  $\text{SO}_2$  to a cold  $\text{SO}_2$  oxidation plant and also to supply  $\text{SO}_2$  mixed with hot  $\text{SO}_2$  from sulphur combustion to a hot oxidation

unit which is part of the original sulphur-burning plant.

In the first part of the new plant, now in operation, the sulphuric acid unit has a nominal capacity of 140 tons/day of 100%  $\text{H}_2\text{SO}_4$  produced as 95%  $\text{H}_2\text{SO}_4$ , in addition to the 120 tons/day produced by the existing sulphur-burning plant.

#### Operation

Pyrites, used at the rate of 100 tons/day, is dried in a rotary drier and ground in an air-swept conical ball mill to give a residue of approximately 20 to 30% retained on

a 200-mesh screen. This fine material is injected in through the roof of one of two flash-roasting furnaces which have the following dimensions: inside diameter, 21 ft. 2 in.; overall height, 38 ft. 8 in.; depth of cone, 15 ft. 2 in. Spontaneous decomposition of the pyrites occurs in this furnace.

The air which supports the combustion is supplied partly as primary air, in which the pyrites is suspended before being injected into the furnace, and additionally in approximately equal quantity by secondary air which enters the furnace through the cinder outlet at the bottom of the cone. The cold secondary air serves to remove the sensible heat from the discharging desulphurised cinder, so that in normal circumstances the cinder leaves the furnace almost at room temperature.

#### Heat recovery

When a 50% sulphur-containing pyrites is burned in air to produce an  $\text{SO}_2$  gas strength exceeding 10%  $\text{SO}_2$ , the exothermic reaction is such that temperatures in excess of 1,000°C. are produced. In older furnaces, particularly those incorporating mechanical devices, much of this heat had to be dissipated or, alternatively, the gas had to be sufficiently diluted so that operations were possible.

With the flash-roasting units installed at Grimsby it is possible to recover all the heat of pyrites oxidation in a waste-heat boiler, and it is also possible to obtain a high  $\text{SO}_2$  strength by recirculating a portion of the cooled gas leaving the waste-heat boiler back to the furnace. The boiler, in fact, operates as an external cooler. In actual operation,  $\text{SO}_2$  strengths of the order of 10 to 13% are obtained with furnace temperatures maintained at 950°C. and steam equivalent to 3 lb. steam/lb. of sulphur burned is produced. The gases leave the waste-heat boiler at 350 to 400°C.

#### Acid manufacture

By means of a train of hot Cottrell electrostatic precipitators, wash towers, mist precipitators and a drying tower, the gas is cleaned, washed and cooled, acid mist is removed, and the gas dried. Centrifugal blowers inject the cold gas via a series of heat exchangers into a four-pass vanadium converter, the heat of reaction of the oxidation of  $\text{SO}_2$  being used to pre-heat the incoming gases to the ignition point. The conversion of  $\text{SO}_2$  to  $\text{SO}_3$  is 98% complete.

$\text{SO}_3$  is absorbed in 98% acid in a conventional absorber, and the 95% acid is produced by mixing absorber acid with the weaker 93% acid from the drying tower. The heat of dilution is removed in water-cooled cast-iron coolers.

Cinder from the roaster, from the boiler and from the hot Cottrell precipitator is collected by means of a drag scraper and elevated to a storage hopper, from which it is conveyed to rail wagons via a pug mill mixer in which the cinder is wetted to

prevent dust nuisance. This cinder is bought by steel works.

Of the three flash roasters, two are employed on the main sulphuric acid plant. The third roaster will produce a gas in a similar manner to that already described. After cleaning and drying, this will be mixed with hot gas from the sulphur burner on the sulphur plant in the proportion of about two parts of hot gas to one part of cold gas, and then fed to the hot gas converter. In this way, the consumption of sulphur at Grimsby will be reduced to approximately 60% of what it was formerly, the acid plant capacity in the meanwhile having been increased by some 125%.

#### Construction

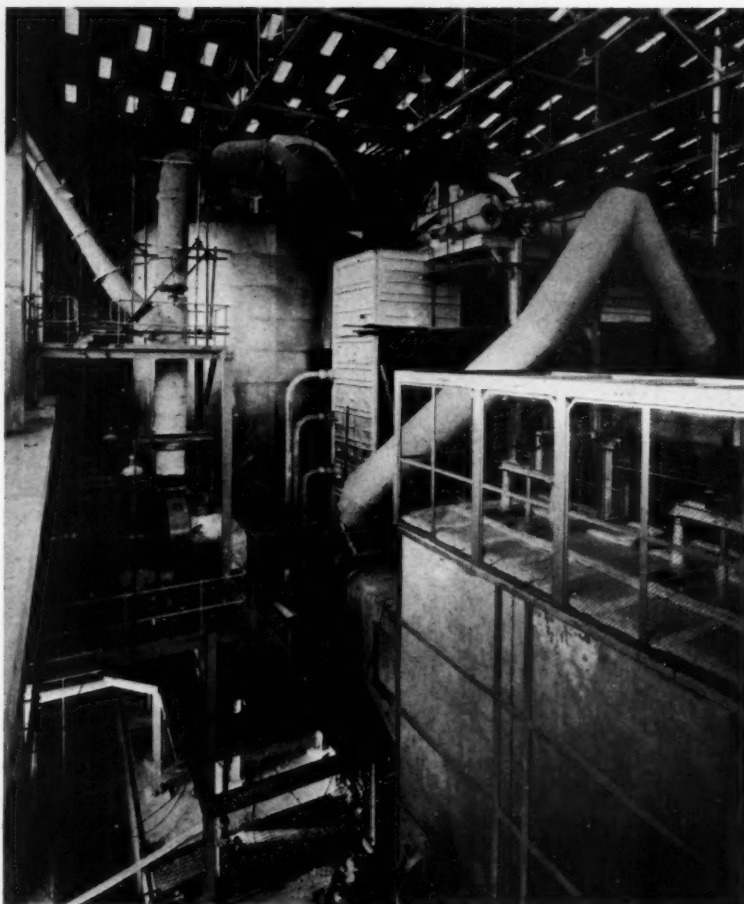
The entire plant, covering an area of about three acres, is built on concrete piles because of the soft nature of the ground. Piling was commenced on March 1, 1951, and was completed in July of that year when the last of 12,092 piles were driven.

The main building is constructed of reinforced concrete columns and beams, and clad in 9-in. brickwork. Column

sizes average 3 ft. 6 in.  $\times$  1 ft. 9 in. section and a total of 4,150 tons of reinforced concrete was used. The building is divided into two parts by a 9-in. thick partition wall which separates the drying and grinding sections from the flash-roasting section. The flash-roaster building contains other buildings, each being virtually independent and having its own roof. These buildings are a transformer house, pump house, instrument house and compressor house.

#### Electrical equipment

The plant has an installed electric h.p. of just under 2,000 with a load factor of approximately .75. It is fed from a 3 mva. substation which has ultimate capacity of 4 mva. Power is transformed down from 11 kv. to 480 v., at which voltage it is fed to the various sections. There are four main load centres, namely, the main blowers, acid manufacture, pyrites roasting, and pyrites drying and grinding. The main blower motors are each 475 h.p. at 3,000 r.p.m. and have an accelerating time of 70 sec. As mentioned, dust extraction from the  $\text{SO}_2$  gas is by means of electrostatic precipitation and washing. Two



The roaster hall, showing in the background one of the three flash roaster furnaces with the rectangular waste heat boiler in front of it. Part of an electrostatic precipitator can be seen in the right foreground.

precipitators are included in the gas stream, one before and one after a wash tower.

In the dust precipitator the voltage is built up to 100,000 and rectified by means of synchronously-driven mechanical rectifiers.

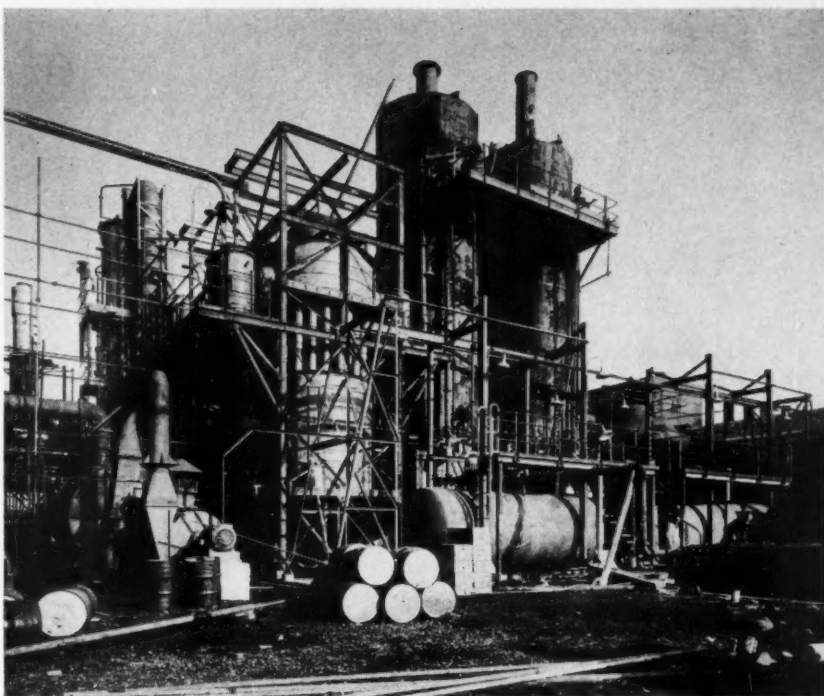
In the mist precipitator straightforward static rectification, also operating at a voltage of 100,000, is used.

#### Instrumentation

The rotary drier temperature is controlled by a mercury-in-steel recorder which, with the bulb in the drier exhaust, regulates a Satchwell-type motorised oil valve. An over-riding temperature recorder at the feed-end ensures that the brick-work does not become too hot. A Radiovisor unit is installed to take care of the furnace in case of flame failure. Pressure and draught conditions at the Hardinge mills are shown by simple manometers.

Each roaster has a panel which is made up of one six-point recorder with thermocouples at strategic positions around the roaster, boiler and circulating-air system. A Multipoint indicator is incorporated on the panel for spot checks and extra measurement points. Two ring balance recorders are used for primary air and recirculating gas flow respectively, and a two-point suction recorder is installed for roaster base and primary air. A double-range instrument records steam flow and pressure, and a bank of four edgewise gauges show pressure and draught conditions around the system. A recorder shows  $\text{SO}_2$  strength of the gas from the roaster.

The acid plant has one instrument panel incorporating the necessary measurement units for centralising control. A Multipoint potentiometric indicator indicates the temperature conditions throughout the plant. The 'Cottrell' gas temperatures are included in this and thermocouples are installed in these and in appropriate positions through the heat exchangers, the primary and secondary converters, and the absorption and cooling towers. Twelve temperatures are recorded on two six-point recorders. Included in these are one each at the inlet and exit of the blower and at the exit of the starting-up furnace. Again, a bank of edgewise gauges indicate pressure and draught con-



Part of the conversion towers and mist precipitators under construction.

ditions throughout the plant, and a ring balance indicator shows the gas flow through the system. A recorder shows the gas strength in terms of percentage  $\text{SO}_2$  at the entrance to the primary converter, and a similar type of instrument records the final acid strength, also as a percentage. A Numicator is installed on each circulating tank, indicating in the control room. As a precaution against water contamination, a recorder measures the conductivity at the cooler and operates an alarm should the purity depart from an adopted standard. A thermostatic device at the cooling tower operates a similar alarm should the gas temperature rise to any extent.

#### Contractors and suppliers of equipment

Co-ordinating contractors: British Titan Products Co. Ltd.

Main contractor: Cyanamid Products Ltd.

Sub-contractor: Simon Carves Ltd.

Flash roaster specialists: Huntington Heberlein & Co. Ltd.

Ball mill and classification of pyrites: International Combustion Ltd.

Electrostatic precipitators: Lodge-Cottrell Ltd. Rotary drier for pyrites: Dunford & Elliott (Sheffield) Ltd.

Blowers: Keith Blackman & Co. Ltd.; Air Control Installations Ltd.

Acid pumps: Sigmund Pumps Ltd.

Conveyors: Barry Henry & Cook Ltd.

Dust collectors: Pratt Daniel (Stanmore) Ltd.

Furnace flame failure device: Radiovisor Parent Ltd.

Multipoint indicators: Elliott Bros. (London) Ltd.

#### Handling materials

'Every time a material is handled something is added to its cost and nothing to its value.' With this aphorism in mind, the authors of this book\* have set out to show how better materials handling can increase productivity and improve the workers' lot. It illustrates how better handling can be obtained with proper use of mechanical equipment when process integration or re-planning will not obviate the handling of the material. The equipment described falls into five categories: runways and lifting equipment; cranes, conveyors; floor transport and storage; and miscellaneous equipment. There is also a short chapter giving case histories of old and new methods of handling which show the advantages of modernisation. The information is reinforced throughout with many photographs and drawings.

\*Materials Handling in Industry. British Electrical Development Association. Pp. 142. Illus.



General view of acid plant showing storage silo, main building and external conversion plant under construction.



# Coke Oven Gas as a Raw Material for Chemical Synthesis

By J. L. Boyle, B.Sc., Ph.D., A.R.I.C.

The many chemical uses which have been found for the liquid products of coal distillation—oil and tar—stand in striking contrast to the few so far developed for the gaseous products. The petroleum chemicals industry is an example of what can be done with a restricted range of gaseous hydrocarbons as raw materials. With this in mind, the author discusses the economic and technical aspects of using coke oven gas for chemical synthesis. His conclusion is that with modern separation processes it is feasible to produce considerable quantities of valuable chemicals from coke oven gas.

THE probable reason for the different course of development taken by the liquid products of carbonisation compared with the gas is that the coal carbonising industry sold the oil and tar to the chemical industry to make what it could of them while keeping the gas for its own use, solely as a fuel. This was the only possible course for that section of the industry making town's gas, for that is the object of its operation. But 45% of the coal carbonised in the U.K. is carbonised in coke ovens where, in most cases, the main product is coke to be used in blast furnaces for smelting iron. In this section of the industry, the gas is as much a by-product as are the liquid products of distillation and a similar diversity of uses could be found for it as for the latter. The fact that a comparatively large volume of coke oven gas—in 1938 there was produced 209,000 million cu. ft., by 1950 it had risen to 246,000 million cu. ft.—was available in Britain could have been a great source of industrial strength, leading to the growth of something akin to the petrochemical industry of the U.S.A. Unfortunately, the opportunity was, in the main, missed.

The gas is disposed of at each works in whatever appears to be the easiest way. In some, it is burned under the ovens to carbonise subsequent charges of coal. In others, it is used in the steel furnaces as an auxiliary fuel, although the steel makers do not think highly of it for this purpose. In a few places, it is sold to neighbouring municipalities as town's gas; about 12% of the gas sold by the gas industry is drawn from coke ovens. In a very few instances, it is taken as a starting point for chemical synthesis. However, usually it is only the hydrogen which is separated and used in ammonia synthesis, while the hydrocarbon portion is returned as a high-grade fuel.

## Hydrocarbons

The use of coke oven gas as a source of hydrocarbons for chemical synthesis does not necessarily involve the separation of all the constituents of the gas. As mentioned above, the removal of hydrogen alone is already practised. To a lesser extent, so also is the removal of ethylene. About 700

tons of ethylene is present in 1,000 million cu. ft. of coke oven gas and by extracting completely the olefines together with a small proportion of the methane—enough to provide the motive power for the extraction plant—the residual gas is decreased in volume by about 8% and its calorific value drops about 70 B.Th.U./cu.ft. This means that the olefines, mainly ethylene, can be extracted and used for synthesis purposes without greatly affecting either the volume or calorific value of the remaining gas which, if so desired, can still be used as a fuel for domestic or industrial use. The extraction of all the methane would leave a gas with too low a calorific value to be saleable as a fuel, but either only one-third of the methane could be removed, leaving a gas of sufficiently high calorific value for sale to the public and to industry, or, by enriching the fully stripped gas with producer gas, it could be made suitable for heating ovens or steel furnaces.

## Coke ovens

Coke oven gas is the gas produced when coal is carbonised under conditions designed primarily for the production of metallurgical coke. Broadly speaking, there are two types of coke ovens: compound ovens and rich gas ovens.

Compound ovens, which are the usual kind attached to an integrated iron and steel plant, can use blast furnace or producer gases for heating and when so operated all their production of coke oven gas is available for outside use. In actual fact, at iron and steel plants, the coke oven gas is usually included as part of the fuel balance and is used entirely as a fuel. From the chemical engineering point of view, therefore, the adaptability of this type of oven is not fully utilised when the gaseous product is treated as just another fuel. In some plants, part of the coke oven gas is used to fire the ovens, a practice which a chemist must deplore. In that case, only 55% is available for outside use.

The second type—rich gas ovens—are found mainly at 'merchant' coke plants which are not integrated with an iron and steel works and sell their coke to the steel industry. In these, only 55% of the coke oven gas is available for outside use, the

rest being used to fire the ovens, though there is no reason why any desired constituent should not be extracted from the whole make before returning enough gas to carbonise the next charge.

The following analysis may be taken as typical of coke oven gas: methane 28%; unsaturates 3.2%; hydrogen 48%; carbon dioxide 2.5%; carbon monoxide 6.5%; nitrogen 11.8%.

It will be seen from this that the gas contains no aromatic hydrocarbons which, invariably, are efficiently extracted from it. The inconsistency of so thoroughly extracting aromatic hydrocarbons having a high calorific value, while ignoring at least equally valuable aliphatic compounds, is discussed below. With regard to the percentage figure given above for unsaturates, for practical purposes it can be taken that 85%, i.e. 2.7% of the total, is ethylene and the remaining 0.5% is a 50/50 mixture of propylene and butylene.

When coke oven gas is used as a fuel, the economic value of its constituent gases is based on their calorific value. For example, if the unsaturated compounds were extracted from the above gas, its calorific value would be reduced from about 525 to about 460 B.Th.U./cu.ft. There would be a reduction of 1 therm in heating value for every 1,500 cu. ft. of gas so treated. If the price per therm for fuel is taken as 1.9 pence, then the economic effect of extracting the unsaturates from 1,500 cu. ft. of coke oven gas is equivalent to this sum. By making similar calculations for each of the important constituents of coke oven gas and applying them to a plant producing 10 million cu.ft./day, the figures in Table 1 are obtained (the figures for crude benzole are included for comparison).

These figures bring out several points of interest. We see that, as a fuel gas, hydrogen is worth much more per ton than any of the other constituents. Yet it is the only constituent of coke oven gas which, until recently, it has been thought worth while to extract on a large scale so that it is not used as a fuel. Synthetic ammonia plants have been set up adjacent to coke ovens so as to draw on the supply of hydrogen which the latter possess. It is only in such circumstance that it would

Table 1

Gas	Daily production		Value		
	$\times 10^3$ cu.ft.	Tons	Per $10^3$ cu.ft.	Per ton	Per day's make
Methane .. .. .	2,800	53	13.5d.	£3.0	£160
Ethylene .. .. .	270	9	21.2d.	£2.67	£24
Other unsaturateds ..	50	2.8	36.2d.	£2.64	£7.5
Hydrogen .. .. .	4,790	11.4	4.4d.	£7.6	£88
Benzole .. .. .	114	10.7	54.0d.	£2.42	£25

be economical to extract the hydrogen, because it cannot be cheaply transported; the user has to be within piping distance. On the other hand, the aliphatic hydrocarbons, if extracted, can be relatively easily transported to the consumer's factory, which need not be near at hand.

The figures for benzole have been included in Table 1 to show that its tonnage is approximately the same as that of the unsaturated hydrocarbons and only about one-fifth that of methane. Again, its thermal value per ton is of the same order as that of the aliphatics, while its value on a volume basis is 2.5 to 3 times as much. If it were necessary to choose between extracting the aromatic and the aliphatic fractions, the above considerations would lead one to prefer the aliphatics, on economic grounds. Why then is it that, in fact, the reverse is practised? It might be thought that power requirements are much less for recovery of benzole; or that the finished product commands a higher price; or that the capital and running costs of a benzole recovery plant are less.

An estimate of the power that would be used to recover the aliphatic gases by a refrigeration process shows that it is only one-half of that needed for a benzole recovery and refining unit, per ton of product. It is not possible to make a comparison of the relative values of the finished products or of the operating costs of the extraction plants, but there is no reason to believe that they would be more favourable to benzole than to methane and ethylene. There is no escape from the conclusion that it is inconsistent, and probably economically wasteful, to recover benzole from the gaseous products of coal distillation while consigning the aliphatic constituents to the flames. The reason for this peculiar policy is that, in the early stages of by-product coking, benzole was the only hydrocarbon that could be economically and efficiently recovered from the gas. Therefore plant was developed and installed for this purpose. There have been many technical developments since then; the position with regard to the hydrocarbon gases has been vastly changed, but, unfortunately, the coke oven industry has not kept fully in pace with these changes.

#### Separation by refrigeration

The separation of hydrogen from coke oven gas is one of the most highly developed applications of refrigeration technique, the uses being for ammonia synthesis and hydrogenation. Incidentally, coke oven

gas is a slightly dearer source of hydrogen than water gas, but much cheaper than electrolytic gas. The extraction of hydrogen entails considerably more purification and, therefore, more complicated plant than is necessary when the main products are liquefied hydrocarbons—an ethylene fraction and methane.

The boiling points at atmospheric pressure of the constituents of coke oven gas are:

	°C.
Propylene .. .. .	-47
Ethane .. .. .	-88
Ethylene .. .. .	-103
Methane .. .. .	-161
Carbon monoxide ..	-191
Nitrogen .. .. .	-196
Hydrogen .. .. .	-252

The two inorganic gases have considerably lower boiling points than the hydrocarbons, and this simplifies the plant necessary for the latter's separation, compared with a plant that isolates hydrogen in a pure state. A decision not to recover hydrogen would be supported by the fact that, as a fuel gas, it is worth two to three times as much per ton as any one of the hydrocarbons; the disadvantage of its high dilution could be overcome by mixing it with the untreated coke oven gas or other rich gas which was to be burned.

Because coke oven gas contains nearly 50% of hydrogen, which has a negative Joule-Thomson effect, the most suitable refrigeration system is likely to be one based on adiabatic expansion in a cylinder. It has been calculated that it would be economically possible, in plants handling more than 1.5 million cu.ft./day, to use a high-speed turbine as the expansion engine for cooling the gas. Either a single-stage De Laval type about 6 in. diam., or a multi-stage turbine having about a 3-in. diam. rotor, could be used. A choice has to be made between operating at high pressure of about 200 atm. or low pressures of about 10 atm., and at present the latter is the preferred condition.

The reasons why high-pressure machines have been used for gas refrigeration in the past are that the minimum work required for liquefaction is less at high pressures; the efficiency of the cooling cycle, therefore, is less important; and the Joule-Thomson effect becomes more efficient when the gas is pre-cooled and expansion begins at a high pressure. But the main source of loss in these plants is due to the low efficiency of the expansion machine, and this is attributable mainly to practical difficulties in the design of a piston engine. At high pressure, a piston compressor is

necessary, but if the process can be performed at low pressure, a turbo-compressor could be used; on the whole, the latter is more reliable, of smaller size and higher efficiency. In a refrigeration process working at low pressure, the overall efficiency is more dependent on the efficiency of the expansion machine than when high pressures are used; also the Joule-Thomson effect is small and so the production of cold falls entirely on the machine. Consequently, the expansion engine must operate at a low temperature and possess a high thermodynamic efficiency. The proper design of the expansion turbine, therefore, is the first essential for a practical liquefaction process for coke oven gas.

The conditions are quite different from those which a steam turbine has to meet. The relative importance of the various sources of losses in efficiency are totally different. When dealing with coke oven gas, the frictional losses in the blading are several times less than when steam is the medium, but friction between rotor and gas is much greater. The main cause of loss in efficiency is connected with the density of the gas. At the operating temperature, the gas density is many times greater than that of steam in a steam turbine and the centrifugal force developed in the turbine causes a radial pressure gradient. This leads to the ejection of gas and adversely affects its regular motion in the blading. In this respect the position resembles more the state of affairs in a water turbine where one is dealing with a medium of high density and, for this reason, an expansion turbine is something of a compromise in design between a steam and a water turbine.

A low-pressure system of refrigeration allows regenerators, which are the most efficient type of heat exchanger, to be used for heat interchange, and they bring with them the considerable incidental advantage of avoiding the need for a plant to dry the gas and remove carbon dioxide. Because the hydrodynamic resistance is smaller in regenerators than in other heat exchangers, the loss due to pressure drop in the piping is less than it would be in any other system. This is so because the moisture and carbon dioxide deposited by the incoming gas are almost entirely carried away by the outgoing gas.

A prototype plant, apparently based on the above principle, has been set up at the Corby coke ovens to recover ethylene. There are two cooling stages; in the first, water, carbon dioxide, hydrogen sulphide, and hydrocarbons with three or more carbon atoms are taken out; in the second stage, ethylene is condensed by indirect heat exchange. The residual gas from which the ethylene has been extracted is expanded in the expansion turbine to produce the cold. It then passes through a regenerator, picking up the condensate deposited on the packing by the raw gas in the first cooling stage. Because only an

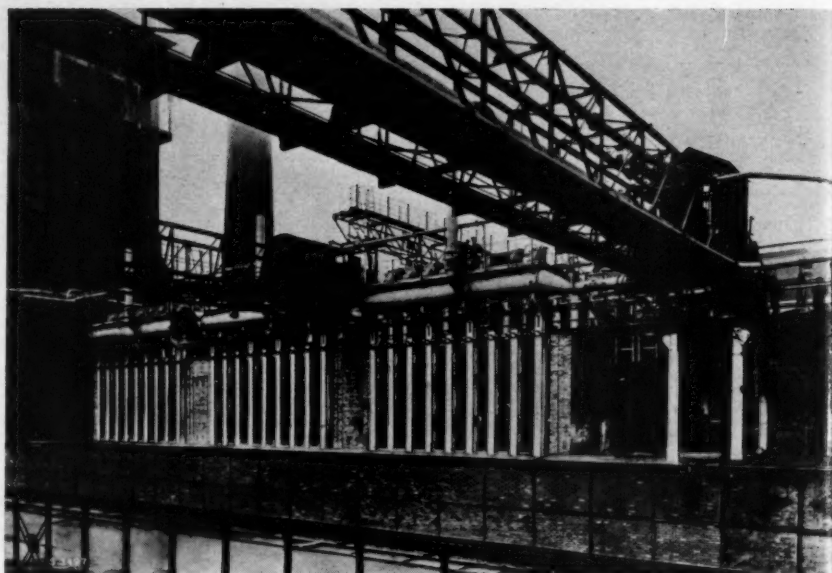


ethylene fraction is being separated, no complex rectification is necessary and it is possible to obtain a temperature as low as  $-180^{\circ}\text{C}.$  with a pressure in the cold section of only 21 p.s.i. The incoming gas is cooled in the regenerator to about  $-135^{\circ}\text{C}.$  In a pre-condenser, about half the ethylene is condensed from the gas by heat exchange with the cold outgoing gas, while the remainder is separated in a reflux condenser cooled by liquid methane. This methane is obtained by cooling the gas a little more in an after-condenser, where a small methane fraction is produced and used as reflux in the methane column and as make-up in the auxiliary methane circuit, which provides the additional refrigeration that the expansion turbine cannot supply. The gas passing through the turbine is expanded from a pressure of 12 p.s.i. to 3 p.s.i. The expanded gas returns through an after-condenser, a pre-condenser and a regenerator to the coke ovens, where it is used as a fuel. The energy produced by the turbine is utilised in a booster which provides the pressure needed to send the gas back to the coke ovens. Two rectification columns separate methane from the crude ethylene fraction and ethylene from the remainder. In the first, the crude liquid ethylene is fractionated into a liquid containing 70 to 75% of ethylene, which is converted in the second column to ethylene of 97% purity and an ethane fraction.

#### Chemical process for separating ethylene

Another process that has been used on the industrial scale is the removal of the unsaturated compounds by scrubbing with concentrated sulphuric acid. The ethylene and its homologues are not recovered as such, but as alcohols or ethers. The process is based on the reaction  $\text{C}_2\text{H}_4 + \text{H}_2\text{SO}_4 = \text{C}_2\text{H}_5\text{HSO}_4$  (ethyl sulphuric acid). The difficulty is that this reaction is very sluggish below  $100^{\circ}\text{C}.$ , whereas at higher temperatures there is a good deal of destruction of the ethyl sulphuric acid by the sulphuric acid. The process was tried many years ago in England using 95% acid at 60 to  $80^{\circ}\text{C}.$  in the presence of fine silica as a catalyst. It was abandoned because of the cost of re-concentrating the sulphuric acid and the fact that the alcohol produced had an offensive odour due to the presence of hydrogen sulphide in the original gas.

Since then it has been found that cuprous oxide is a good catalyst for the reaction and allows weaker sulphuric acid to be used at lower temperatures. The process, as carried out in France, consists of a preliminary cooling of the gas to reduce the water content, washing with sulphuric acid to remove hydrogen sulphide and higher homologues of ethylene and then washing out the ethylene by bubbling it up packed towers down which sulphuric acid, containing 4 to 5% cuprous oxide, is circulated at 30 to  $40^{\circ}\text{C}.$  About



[Photo: Imperial Chemical Industries Ltd.]

A battery of 24 rich gas coke ovens built by Simon-Carves Ltd. at Billingham. These ovens are used to make coke, which in turn is used to produce water gas for synthesis.

1.6 tons, i.e. 200 gal., of acid are used each 24 hr. per million cu. ft. of gas treated. The mixture of acid and ethyl sulphuric acid is diluted with water to produce ethyl alcohol and sulphuric acid. The ethyl alcohol is distilled off; the acid centrifuged to remove the catalyst—which is re-used—and the acid is sent to the ammonium sulphate plant, for which it is good enough.

The capital cost of this process is much less than that for any other process and it has what might be an attractive feature in certain circumstances in that it is flexible and could be adapted to deal intermittently with relatively small volumes of gas for which there is temporarily no profitable outlet, such as production in excess of fuel requirements. Unfortunately, the equivalent of only about 50% of the ethylene in the gas is recovered.

#### Hypersorption

Hypersorption is a process developed in America for separating gases, particularly those for which refrigeration and other existing methods have been considered to be uneconomic. It depends on the ability of activated carbon to adsorb heavier gases or larger molecules to a greater degree than lighter gases or smaller molecules. So far as the writer knows, it has not been used for coke oven gas separation, but it has been applied to the similar problem of separating ethylene from petroleum cracking-unit gas.

The selectivity of activated carbon for various components is generally dependent on their relative volatility. Thus, ethane and ethylene may be separated on the one hand from methane and on the other from propane and propylene. The selectivity between saturated and unsaturated

compounds containing the same number of carbon atoms is less pronounced.

The feed gas is introduced into the centre of a column containing a slowly moving bed of activated carbon. This adsorbs mainly the heavier components and passes to a rectifying section where it meets a counter-current reflux of the bottoms product which displaces any of the lighter overhead components originally adsorbed from the feed. The adsorbed gases are stripped from the carbon by steam fed into the carbon bed below a heating section and passing up through tubes externally heated by condensing *Dowtherm* vapour. The stripped carbon is raised to the top of the *Hypersorber* tower and recirculated. The operating pressure depends on the pressure at which the feed gas is available, but when this is low, as in the case of coke oven gas, it is preferable to compress it to around 200 p.s.i. before starting separation.

If this were applied to coke oven gas, the intention would probably be to produce an overhead fraction containing methane and the lighter components, to be used as a fuel gas, with a side cut of pure ethylene and a bottoms product containing the heavier hydrocarbons.

#### Separation by thermal diffusion

The principle of thermal diffusion has been suggested as a basis for a method of separating the constituents of coke oven gas. If a thermal gradient is set up within a gas mixture, the heavier molecules will concentrate in the cooler region and the lighter ones in the warmer section. The idea has been applied on a large scale by making an electrically heated wire running down the centre of a vessel the hot point, while the walls are cool. As well as the



molecules diffusing horizontally between the hot and cool regions there is a heat-syphoning action which causes the gas near the hot wire to rise and that near the cool wall to fall. The efficiency of separation is influenced by the partial pressures of the components, their relative densities and the temperature difference. By using hot gas as the feed, it is possible that it would only be necessary to supply sufficient power to cool the walls in order to separate the hydrogen from the other constituents. The residual gas would then be processed so as to separate methane and ethylene more cheaply.

#### Outlets for carbonisation gases

The unsaturated hydrocarbons, and particularly ethylene, are the most attractive proposition. There is a very good market for polystyrene and the monomer, styrene, is made by combination between ethylene and benzene. This would be a very suitable outlet for ethylene from coke oven gas, because the other raw material, benzene, is already produced in large tonnage at coke ovens. In fact, the new British plant at Grangemouth, which is being built to make polystyrene, has contracted to draw its supplies of benzene from coke oven sources, but the ethylene will be obtained from the cracking towers of the petroleum refining plant. From the point of view of using indigenous raw materials, it would seem better that both the ethylene and benzene should be drawn from coal distillation products. Actually, the ratio of ethylene to benzene produced

at a coke oven plant is nearly twice that needed for the balanced production of styrene, and estimating the price of ethylene on the basis of the reduction of calorific value discussed earlier, we find the material cost for ethylene to be £2 per ton of benzene converted.

Other plastics that use large quantities of ethylene are polythene, which is polymerised ethylene, and polyvinyl chloride. Another new outlet for ethylene is synthetic fibres. The new I.C.I. fibre *Terylene* uses ethylene glycol as one basic raw material. Apart from these applications, ethylene has a very wide range of uses in the chemical industry.

Although the extraction of methane would affect the calorific value very much and, in fact, leave a gas that would be useless as a fuel, nevertheless there is a great deal to be said for separating, at least, part of it. Its actual and possible uses are legion. It would be a valuable enriching agent for any fuel gas and has definite possibilities as a motor fuel. By chlorination and bromination it is converted into compounds used in bulk as refrigerants, fire extinguishers, fat solvents, paint solvents and dry-cleaning liquids. By oxidation, it gives methanol and formaldehyde. It is a possible raw material for the production of acetylene.

From the above discussion it is clear that an extensive range and quantity of synthetic chemicals could be made from coke oven gas and that processes suitable for the separation of the gases are known. However, it would be necessary to divert the raw material from fuel purposes.

### Infra-red checking of effluents

Elimination of hydrocarbon oil and phenols from effluent waters has long been a concern of the petroleum industry. With increasing activity in the field of stream pollution abatement, the search for more sensitive and accurate analytical methods for water contaminants has been intensified. R. G. Simard, *et al.* (*Anal. Chem.*, 1951, 23, 10) report an infra-red method of determination which is sensitive to 0.1 p.p.m. of oil and 10 parts, or less, per billion of phenols.

Developed at the Atlantic Refining Co., Philadelphia, the method is a part of the industry's pollution abatement programme. Accuracy is believed to be better than that obtainable by existing methods at the lower concentrations and is not affected by the volatility of the material being determined. Time per determination is far less than by conventional methods.

Phenols are determined by bromination of the phenols in the water sample, followed by extraction with carbon tetrachloride, and measurement of the optical density at 2.84 microns. Oil is determined in the same  $\text{CCl}_4$  extract by measurements in the 3.4 micron region.

Equipment used was a Perkin-Elmer Model 12-A infra-red spectrometer, with

LiF prism and 50-mm. demountable glass cell with quartz windows. Sensitivity of the method is shown in Tables 1 and 2 below.

These data were all derived from synthetic and not actual waste samples. However, enough work has been done to show that the method will work, except on occasional samples that form a stable emulsion with carbon tetrachloride.

Wavelengths in the same general region of the spectrum were selected to simplify the instrumentation problems. A lithium fluoride prism was chosen so as to determine phenols, as well as oils, with the same prism.

Table 1. Sensitivity of Phenol Method

Compound	Phenol present p.p.m.	Phenol found p.p.m.	Recovery %
Phenol*	0.01	0.008	80
o-Cresol†	0.01	0.006	60
	0.012	0.016	133
	0.031	0.034	110
	0.049	0.054	111
	0.061	0.078	128

\*Phenol calibration used  
†o-Cresol calibration used

The synthetic mixtures were prepared by weighing the required amount of oil

Table 2. Sensitivity of Oil Determination\*

Waste oil added p.p.m.	Waste oil determined p.p.m.
1.2	1.1
1.2	1.0
0.1	0.1
0.1	0.1
0.0	0.04

\*Water extracted with 10 ml. of  $\text{CCl}_4$  per litre

into the bottle of water, followed by at least 15 min. of violent mechanical agitation. Less agitation was required in preparing the synthetic phenol mixtures, owing to the solubility of the phenols in water.

Conventional analytical methods for phenol determination involve formation of a coloured indophenol or nitrosophenol. Oil determinations according to classical methods require gravimetric or volumetric techniques employing extraction or distillation, and are limited to concentrations above 1 and, preferably, 10 p.p.m.

**Gas-making oils.** Methods of evaluating oils for gasification are presented in two new numbers of the Institute of Gas Technology Research Bulletin Series, No. 9, 'Selection of Oils for Carburetted Water Gas,' and No. 12, 'Selection of Oils for High-B.Th.U. Oil Gas.' Both are co-authored by E. S. Pettyjohn, the Institute's director, and H. R. Linden, assistant research director. The projects on which these publications are based were sponsored by the Gas Production Research Committee under the P.A.R. Plan of the American Gas Association. The bulletins present data on the relationships of the physical and chemical characteristics of petroleum fractions, and of the operating variables, with the enriching values and with the qualities and quantities of the gaseous and liquid products. For the more common gas-making oils, these data are given in graphic as well as tabular form. Nomographs and equations included in the bulletins permit accurate calculations of these values for any oil, and indicate the operating variables most suitable for the selected oil and most favourable distribution between gaseous and liquid products. Estimates of enriching value and oil gas yields, arrived at by the methods outlined, were compared with results obtained in plant operation, and found to be in good agreement, demonstrating the reliability of the procedures.

**Industrial instruments.** In their latest publication, *Nullmatic Industrial Instruments*, Sunvic Controls Ltd. give full details of their control instruments, including control stations (miniature panel), liquid-level transmitters and controllers, flow controllers, pressure regulators and thermometers, etc., with details of applications, installation and maintenance. The catalogue is in loose-leaf form and it is illustrated with photographs, charts and diagrams.

# FILTRATION

## Theory; experimental data and design; equipment and applications; filter aids and media

By E. L. Streatfield, B.Sc., F.R.I.C., M.I.Chem.E.

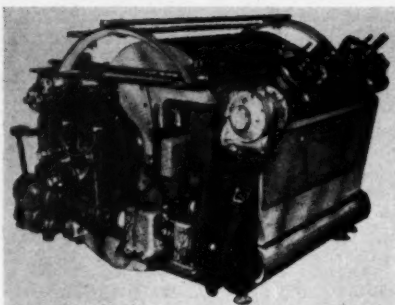
AS previously, this review nominally covers the preceding 12 months, although a number of earlier references have been included in some instances for the sake of completeness. The subject of this review is conventional filtration, i.e. the separation of undissolved solids from liquids by methods other than centrifuging, sedimentation and adsorption.

Theoretical aspects of filtration have been covered in an excellent manner by Rietema<sup>1</sup> in a survey of filtration theories, in which he discusses the 'blocking filtration' and 'cake filtration' theories. Rietema concludes that general laws for blocking filtration cannot be laid down from a consideration of the work of Hermans and Bredée and of Heetjens and Van de Haas. In developing the cake filtration theory an equation may be derived, based on the cake build-up and the pressure distribution through the cake. Kozeny's equation for the relation between permeability and porosity of compressible cake gives the dependence of filtration rate on the porosity distribution in the cake.

A review of the principles of filtration has also been given by Wilson<sup>2</sup>, who describes the effect of particle size and concentration on the properties of suspensions, and reviews the principles of filtration for both liquid and gas suspensions and for clarification as well as for cake type filtration. Wilson describes the mechanisms of separation used in various types of filtration such as mechanical blocking, collision and adhesion, and electrical attraction, and factors affecting power consumption in filters, such as properties of the fluid being filtered, dimensions and structure of the filter bed and pressure drop across the bed.

Although there has been little new work on theoretical considerations of filtration, Sillén<sup>3,4</sup> has contributed two further papers in his theoretical study of filtration through a sorbent layer. In these papers the theory of equilibrium and non-equilibrium processes in sorption columns is discussed critically.

It should also be mentioned that Miller<sup>5</sup> has reviewed very fully in the American literature, with 172 references, papers published in 1951, dealing with filtration theory, filter design and applications, filter aids and media, etc.



[Photo: Eimco (Great Britain) Ltd.]

**Precoat filter.** This machine is of drum-filter design, but uses the principle of pre-coating the drum with diatomaceous earth or other material that will form a coating 2 to 3 in. thick upon the drum. The scraper blade of the filter is movable and feeds in, to shave off a predetermined thickness of precoat during each revolution. This is usually between 0.00035 in. and 0.009 in. per revolution, but may be regulated as desired. The thickness of the cut is determined by the amount that must be removed to leave a clean filtering surface throughout the operation. Precoating time varies from 30 to 60 min. Operating time on one precoat depends entirely upon the speed of the filter and the thickness of the cut; usually it is not more than one month. Machines of this type are becoming popular in industries such as brewing.

Another new 'Eimco' machine is the top-feed drier, a combined top-feed filter and rotary drier. It is used for filtering and drying in one operation, granular products such as salt, foundry sand and ammonium sulphate. The machine incorporates a streamlined hooded assembly which directs a flow of heated air through the cake on the drum. The moisture content of the cake can be reduced to a point where the material can be easily handled by a cyclone.

### Experimental data and design

Several papers have been published recently describing experimental filtration studies, thereby leading to improvements in filter design. Mondria<sup>6</sup>, in a study of cake impurity and liquid yield by continuous filtration, has derived formulae concerning the separation of solids from liquid by a continuous filtration procedure, consisting of the filtration proper and the washing of the filter cake by a suitable wash solvent. In the derivation of the formulae, it has been assumed that the mixture of solids and liquid to be filtered is pre-diluted with a low viscosity liquid

in order to make possible or to speed up filtration. However, the formulae may easily be adapted to cases where no pre-dilution is used. The beneficial effect of filtrate recirculation on the degree of separation already shown in filtration practice, has been worked out quantitatively. On applying the formulae to the dewaxing of butanole-benzole mixtures, used both as diluent and as wash solvent, good agreement with practical results was obtained.

Hoffing and Lockhart<sup>7</sup> have studied the resistance to filtration of mixtures of graded silica dust and of diatomaceous earth made up to give a wide range of filter resistance. The filtering characteristics of these mixtures as slurries were compared with permeability measurements on the powder. The effect of addition of diatomaceous earth was to increase the porosity of the mixtures over silica dust alone whatever the size range of diatomaceous earth chosen.

Lyons<sup>8</sup> has obtained plant and laboratory data on the surface moisture (M%) retained by particles of mean diameter  $D$ , which show that for all types of vacuum filter tested  $\log M$  rises linearly as  $\log D$  diminishes. The slope of the graph is the same for coal slurries, for magnetite and oolitic haematite concentrates, and for sulphide ore and fluorspar flotation concentrates, but it shifts towards lower  $M$  for the three successive groups.

The factors influencing the 'washing' of filter cakes have been studied extensively by Crosier and Brownell<sup>9</sup>. They consider that the mechanism of washing can be divided into three stages: a primary displacement stage which terminates at the break-through point when a portion of the wash first emerges from the filter cake, a secondary stage in which the concentration of filtrate in the effluent from the bed is decreasing continuously, and a final stage in which diffusion of final traces of filtrate from the interstices of the filter cake into the wash stream is the controlling factor.

An investigation into the rotary vacuum filter cycle as applied to sewage sludges has been made by Half<sup>10</sup>. Assuming that the filtration process involves the removal of liquid from a fixed volume of solid and liquid under constant vacuum, the theoretical relation between time factor and filtration accomplished can be determined



from an equation of the heat conduction type developed by Fourier.

### Equipment and applications

The patent literature contains a number of interesting references to inventions claiming improvements in design of filter equipment. Many of these inventions concern filter elements. In one invention<sup>11</sup> detachable filter elements for supporting filter sheets are constructed from corrugated sheets of corrosion-resistant resin or metal.

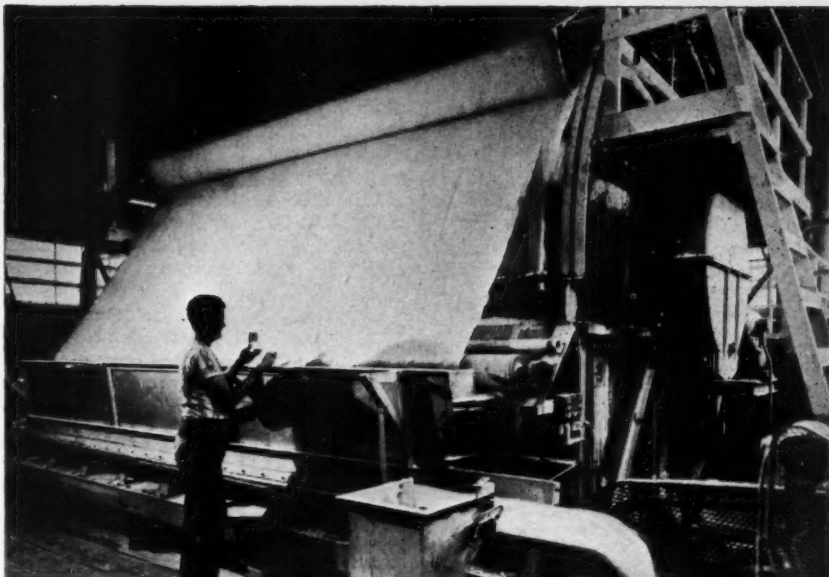
A rigid filter cartridge with a sealing ring for insertion into a cylindrical casing, providing a complete filter unit for oil pipe lines, is the subject of another invention<sup>12</sup>. A filter assembly<sup>13</sup> for fuel or lubricating oils, employs the filter medium in the form of a gauze sheet, clamped between an inlet and outlet assembly under which is fitted a bowl capable of being rotated. Holes in the lid of the bowl enable the flow to be varied.

Felted fibre filter elements<sup>14</sup> may be formed by applying vacuum to a perforated former immersed in an aqueous suspension of the fibre. As the fibre is gradually withdrawn from the suspension, jets of liquid are directed against the filter element to trim it to the desired contour. A similar arrangement is described in another patent specification<sup>15</sup>. A filter element is also described<sup>16</sup> comprising a sintered mass of powdered metal having a high degree of porosity, supported between perforated metal sheets, the perforations therein having been reduced in size by rolling, so that they are able to retain the powder and yet remain permeable.

An element for demulsifying a filtering fluid is described<sup>17</sup>, comprising a chamber containing fibrous material and having a number of spaced vertical partitions dividing the fibrous material into a number of separate sections to minimise the tendency for the material to settle. A further development is also described<sup>18</sup>, whereby a fluid such as gasoline is first freed from foreign matter and is then demulsified. Miscellaneous types of filter elements are also described in a number of patent specifications<sup>19, 20, 21, 22</sup>.

New designs of multiple filter assemblies are described in several patents. Many of the filters described have self-cleaning arrangements. One such<sup>23</sup> consists of a row of cells supporting filter material in their mid parts, the effluent passing from the cell bottoms. Cleaning of one cell at a time is effected by movable apparatus which backwashes cleaning fluid upwards, the fluid being removed from the top of the cell. The operation of the apparatus is not interrupted during cleaning. A somewhat similar design<sup>24</sup> employs in a tank a number of porous filter bags connected to a manifold for taking away the filtrate and conveying wash water. Movable coiled wire members are employed as scrubbers to remove the filter cake.

Improvements in the design of edge



[Photo: Stockdale Engineering Ltd.]

The 'FEinc' String discharge rotary vacuum filter, designed by Filtration Engineers, Inc., U.S.A., is now being manufactured in Britain. The string discharge allows the filter cake to be lifted from the drum surface in one continuous sheet, and, it is claimed, frequently gives a cleaner extraction of cake than is possible with the normal blade discharge. The string discharge does not subject the filter cloth to any severe mechanical strain or abrasive action, and the filter is therefore able to operate with cloths of light fabrics and secure long operating life. Light fabrics, having physical properties very close to those of the theoretical desired media, allow the cake, rather than the cloth, to act as the filter medium.

type filters are also described. In one invention<sup>25</sup> a filter medium of the edge filtration type comprises discs or strips of paper made of material having hollow fibres such as cotton, impregnated with a water-proofing material such as nitrocellulose, so as to fill only a small proportion of the hollow fibres. This process renders the paper discs or strips resistant to loss of identity when wetted while enabling the remainder of the hollow fibres to absorb their maximum capacity for water and permit only the other liquid, for instance oil, to pass the filter. Another design<sup>26</sup> of edge type filter employs a thin narrow ribbon made of plastic material wound in the form of a helix.

Rotary drum filters are the subject of a number of inventions, the improvements cited usually involving either means of feeding the slurry on to the filter cloths, means of supporting the filter cloths or means of cleaning the filter. For instance in one invention<sup>27</sup> the slurry is fed into the angle of nip between two drum filters rotating away from each other above the line joining the filters. Another invention<sup>28</sup> described a rotary drum filter assembly for treating large volumes of liquid with a finely divided filter aid such as sand, and subsequently separating the cake from the

filter aid. A somewhat similar arrangement is described in another patent specification<sup>29</sup>. In another patent specification<sup>30</sup> three rotary vacuum drum filters are mounted in series, and the solid residues and filtrate are fed in opposite directions, discharging cake from the final filter and filtrate as liquid products dissolved in solvent from the initial filter. Another invention describes<sup>31</sup> a rotary drum vacuum filter adapted to dewatering liquid sludges without the progressive loss of filter efficiency owing to binding of the filter medium, while another describes<sup>32</sup> improved means of fixing filter cloths on panels of the drum body. Other improvements concerning rotary filters of various types are described in a number of patent specifications<sup>33, 34, 35, 36</sup>.

A large number of miscellaneous improvements in filter design and applications may also be cited: domestic water filters<sup>37, 38</sup>; lubricating oil and fuel oil filters<sup>39, 40, 41, 42, 43, 44, 45</sup>; combined filtering and centrifugal separation of a liquid from a sludge<sup>46, 47</sup>; cleansing arrangements for straining cloths, e.g. Fourdrinier wires<sup>48</sup>; horizontally mounted filter plates with special spacer rings for acids, oils, syrups, etc.<sup>49</sup>; continuous cleaning of pump strainers<sup>50</sup>.

### Filter aids and media

A useful review, with 21 references, of filtration with the aid of kieselguhr has been given by Van der Heide<sup>51</sup>, while on the other hand, Sanchis and Merrell<sup>52</sup> describe the use of diatomaceous earth filtration on a large scale at Los Angeles for public water supply requirements. In their article they give a useful description of the basic features of the diatomite method of filtration, and then proceed to describe the results of their investigations into the use of commercial diatomite



filters, filter aids, filter elements, backwash requirements, and the effect of activated carbon.

The preparation of porous filter media is described in the patent literature. In one invention<sup>63</sup>, bentonite or diatomaceous earth is coated with a copolymer of vinyl acetate and vinyl chloride (and optionally a germicide) to provide a porous filter medium, especially useful in the purification of water. Another filter material of dolomitic origin is prepared<sup>64</sup> from dolomite in a rotating kiln.

A means is described<sup>65</sup> of reactivating filter media comprising a granular inert material coated with a powdered adsorbent, e.g. coke coated with diatomaceous earth, adsorbent clays and activated carbon. The reactivation process consists in heating the material in an atmosphere of oxygen to a temperature at which the absorbed materials are burned off.

Comparative studies of vacuum filter cloths have been made by Joseph<sup>66</sup>. Various types of filter cloths were rated on their performance in the filtration of sewage sludge. On the basis of performance only, plain wool, napped wool and napped cotton rated in the order given. When costs were included the ratings were in the order, napped cotton, plain wool and cotton twill. Other cloths studied were vinyon, silk, plain cotton, glass and nylon.

The preparation of an alkali-resistant filter cloth is described in a patent specification<sup>67</sup>, whereby filter cloth is given a single impregnation with an aqueous emulsion containing a salt of cerium zirconium or lanthanum, amorphous mineral wax, alkali to give pH 7-9, and a buffer.

### Water, sewage and industrial wastes

Among general papers on water filtration there is one by Naumann<sup>68</sup> in which he discusses the construction and operation of rapid filters and suggests new goals and points of view, and a paper by Waddington<sup>69</sup> in which he discusses filtration methods in relation to the impurities in raw water. A description of the work of the Water Pollution Research Laboratory on water, sewage and industrial wastes involving filtration studies, is included in the Annual Report of the Water Pollution Research Board<sup>70</sup>.

For large-scale water filtration, sand continues to be the filter medium most generally used, although a number of references in the literature to the use of graded anthracite show considerable interest in the use of this material as a filter medium. Thus, Streatfield<sup>71</sup> gives a short review of the experience obtained in filter plants in America using graded anthracite and describes similar experience in a number of recent filter plants in the U.K. Simpson and Whelan<sup>72</sup> describe an apparatus and test procedure for running an accelerated performance test on anthracite filter media. They found that the hardest

anthracite had the lowest volatile matter content.

Michan<sup>63</sup> has made an attempt to evaluate pressure diagrams for sand filters, by plotting on ordinary graph paper, water pressures at various filter levels against levels of water and sand, as a quick and simple means of studying the various factors affecting the efficiency of a given sand filter. In interpreting the results, measurements of water turbidity and filter clogging must also be taken into consideration.

The design of filter floor underdrain systems has received considerable attention. The use of porous ceramic type plates as filter underdrains has been described by Roe<sup>73</sup> and by Berkeley<sup>74</sup>. In an invention<sup>65</sup> described in the patent literature, filter floor nozzles are arranged to be individually adjustable vertically



[Photo: Niagara Filter Corporation]

Closed pressure type alluvial-leaf filter. Within a pressure tank a series of double-faced metal screen assemblies (the leaves) comprise the filter elements which hold back the undesirable solids and discharge a clear product into the common filtrate manifold on which they are mounted. The metal leaf is solderless and all-stainless steel. It is constructed with fine-mesh wire cloth which, it is claimed, provides a surface for utilisation of the finest filter-aids. These leaves are designed to reduce pressure drop across the filter, promote uniform cake building and ensure complete flushing of leaf interiors. Bottom drainage, radiused corners, and open tubular frames make these leaves internally self-cleaning.

High rates of flow, two to five times greater than the conventional cloth-covered presses, are claimed for this filter. It can be constructed from numerous corrosion-resistant metals. The unit sizes range from 20-510 sq. ft. of filter area with capacities of 10 gal./mm. to 15,000 gal./hr.—even where filtrate must approach zero turbidity. Where filtrate must be maintained at a specific temperature, the pressure-leaf filters are supplied with steam jackets or special insulation. The complete enclosure of the machine is of particular importance where solutions being handled are explosive, toxic, inflammable, or volatile.

from above so as to ensure equal flow from each of them, and uniform washing of the bed.

Modifications in filter plant design and modernisation of existing filter plants are described in several papers<sup>66, 67, 68, 69</sup>.

The use in water analysis of molecular filter membranes derived from cellulose for filtering and concentrating micro-organisms from water samples is also widely noted<sup>70, 71, 72, 73</sup>.

Two papers describe the removal of oil from boiler feed water by means of diatomaceous earth filters<sup>74, 75</sup>.

In sewage purification, trickling filters continue to receive considerable attention. Mohlman and Hardenbergh<sup>77</sup> give detailed results of the performance of high rate percolating filters at plants in the sanitary district of Chicago. Heukelekian *et al.*<sup>78</sup> have described the performance of high-rate trickling filters operated in series and in parallel, and Grantham<sup>79, 80</sup> has described the performance of trickling filters at intermediate loading rates and also the progress of purification during the starting of a trickling filter employing slag. Shroepfer<sup>81</sup> has studied the effect of particle shape on porosity and surface area of trickling filter media and Shroepfer *et al.*<sup>82</sup> have made a statistical examination of the effects of temperature on the biological life within a trickling filter and also the effects of temperature on plant operating results and on natural ventilation in trickling filters.

Pettet *et al.*<sup>83</sup> have reported results on the rapid filtration of sewage effluents through sand and anthracite. They found no significant differences in the quality of the effluents, and the suspended solid content of humus tank effluent can be reduced by 72-98% and the BOD value by 50-90%.

The biological filtration of kraut and pickle wastes is described by Haseltine<sup>84</sup> and Davy describes the pretreatment of milk wastes to reduce plant load by means of a high rate trickling filter with provision for recirculation.

The treatment of radioactive wastes has been described by Straub<sup>85</sup> and by Newell and Christenson<sup>87</sup>. Essentially the methods of treatment involve coagulation, sedimentation and sand filtration. Filters are backwashed in the conventional manner to remove radioactive as well as the usual accumulated material. The filter sludge is concentrated either by evaporation or dewatered by vacuum filtration and then buried in drums.

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[Photo: Doulton & Co. Ltd.]

The 91A heavy-duty filter unit. This is intended for use in the filtration of both gases and liquids and, it is claimed, incorporates many few features in design which make the operation of assembly or stripping down for cleaning very simple and result in the filter presenting the lowest possible resistance to fluid flow. The unit is particularly suitable for use in pneumatic or hydraulic control systems.

The casing is in two parts and is available in either cast bronze, aluminium or steel. A hanging bracket on the head is optional and, when it is fitted, alternative castings provide for either left-hand or right-hand inlet connection.

Grades G5 and G6 are used as filters for both air lines and in hydraulic systems, and exhaustive tests are being conducted with these two grades over a wide range of pressure conditions and for long periods of operation. A  $1\frac{1}{2}$ -in. diameter  $1\frac{1}{2}$ -in. long grade G5 filter element will pass 9 cu. ft./min. of air or 70 gal./hr. of water for a pressure gradient of 1 p.s.i.

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- <sup>15</sup>U.S. Pat. 2,539,767.
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- <sup>17</sup>Brit. Pat. 672,737.
- <sup>18</sup>Brit. Pat. 678,025.
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- <sup>24</sup>Brit. Pat. 665,203.
- <sup>25</sup>Brit. Pat. 682,400.
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- <sup>30</sup>Brit. Pat. 672,700.
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- <sup>32</sup>Brit. Pat. 667,857.
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- <sup>35</sup>U.S. Pat. 2,560,142.
- <sup>36</sup>Brit. Pat. 678,126.
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- <sup>38</sup>U.S. Pat. 2,541,824.

- <sup>39</sup>Brit. Pat. 656,494.
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- <sup>42</sup>Brit. Pat. 660,594.
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- <sup>44</sup>Brit. Pat. 662,282.
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## Future Articles

Reviews of 'Mixing' and 'Centrifuging'; 'Acid Recovery at a Solvents Plant'; 'Future of Petroleum Processing'; 'Synthetic Liquid Fuel Plants.'

Owing to pressure on space the last two articles are held over from this issue.

## New Books

### Industrial drying

The value of efficient drying processes to industry has grown in recent years with the great need for fuel saving. The exchange between those concerned of up-to-date information on drying problems can help to speed the use of methods of drying that may lead to improved efficiency and output.

Some time ago the D.S.I.R. undertook the preparation of a bibliography of drying as a contribution to chemical engineering research. The bibliography\* has now been published. The compilers have managed to find some 4,500 references in the period 1924-50. The first two sections of the work deal with principles, processes and equipment, and include a limited number of references on heat transfer and drying of gases. A further three sections cover the various drying methods that can be used in agriculture, in the food processing industry and in the drying of industrial materials. Each section is divided by sub-headings under which the references are listed alphabetically.

\**Bibliography of Industrial Drying*. Dept. Scientific and Industrial Research. London, 1952. Pp. 800. 28s. 7d., including post.

### The Glycols

The large modern plants for the manufacture of glycols, of which the new I.C.I. unit in this country is one of the latest examples, strikingly emphasise the modern industrial importance of these chemicals. Yet until 1925 they had little commercial importance. Since then a great deal of information on glycols has been published, but there have been few attempts to assemble it in a form convenient for reference. It is to this task that the authors of this book\* have addressed themselves, and they have done their work with great thoroughness. The book is chiefly concerned with the two most important glycols, ethylene and propylene. Particularly valuable is the emphasis on manufacturing techniques. Details are given of the two commercial methods for producing ethylene oxide and one chapter is devoted to the ethylene glycol condensation polymers. Propylene glycol is treated in the same detail with information on production, physical properties, commercial applications, the ethers, esters and acetals, and the condensation polymers.

Already the glycols are firmly established as the raw material for detergents, plastics, synthetic fibres, anti-freezes, etc., and their uses are continually widening. This book is thus a timely volume which will find readers in all branches of the chemical and process industries.

\**Glycols*. Edited by G. O. Curme, Jun., and F. Johnston. Reinhold and Chapman & Hall, 1952. Pp. xii + 389. 96s. net.



# Pyrites Mining and Preparation

*Appreciating the heightened interest in pyrites for acid making which has developed since the sulphur crisis of 1951, the Fertiliser Society recently organised a symposium in London on the mining and preparation of pyrites for acid making. The contributors were representatives of the Rio Tinto Co. Ltd. and the St. Joseph Lead Co. Between them they covered all aspects of the subject in a series of six papers from which the following abstracts have been taken.*

**M**OST of the Rio Tinto pyrites come from the large San Dionisio Orebody, which is divided into two parts, the eastern end, the Alfredo Mine, worked by underground methods, and the western end, the Atalaya Opencast, worked by opencast mining.

## Extraction

Two methods of extraction are used in mining the opencast: normal benching using steam and electric shovels, and Glory-holes and scrapers loading into chutes. The present system of mining the underground section is one of bottom-slicing and filling with roof settlement. The method consists of extracting, floor by floor, the block of mineral lying between two of the old transverse stopes. Each block forms one stope, measuring 100 m. long by 30 to 80 m. wide by 12½ m. high. Each stope is extracted by a series of cuts across the orebody, beginning at the floor level and working upwards to the floor above. After each 50 or 60 tons have been extracted the voids are filled, as the safety and stability of the whole stope depends on filling keeping pace with extraction, thus giving even and controlled ground settlement.

The constantly subsiding floor makes mechanisation impracticable, and necessitates hand-filling in the loading and tramping of the ore in the stopes, which is the biggest check to increased production. A possible answer to this problem has been recently found in the adaptation of pneumatic stowing, which can reduce the amount of settlement by producing a more compact fill.

## Crushing and screening

The Rio Tinto crushing plant is designed to produce an ore with not more than about 1% +½ in. and the minimum amount of -60 mesh, used by the majority of pyrites burners today. It produces standard furnace-size lumps for export and screening lumps from the 'run-of-mine' ore for the smelter. The plant consists of two units, the No. 1 for treating washed ore and the No. 2 for treating ore from the mine. In the latter case the mineral from the mine is tipped into two receiving bins, from which it is drawn by push feeders, and passed over a 2-in. Grizzly, the fines going direct by conveyor belt

for the first screening, and the lumps going to a 36 in. × 18 in. Traylor jaw crusher, set to 5 in. The ore is then taken by conveyor belt with the fines to two three-deck 48 in. × 96 in. Niagara screens. The +1½ in. cupreous ore is taken to storage for the smelter; the -½ in. to storage for export, and the +½ in. -1 in. to a 5½-ft. Symons cone crusher set to ½ in. After crushing, the ore is passed over a group of four 48 in. × 102 in. Gyrex screens, fitted with ½-in. screen cloths, the fines going to storage for export and the oversize to three sets of 42 in. × 18 in. Traylor rolls, set at ⅞ in. It enters a closed circuit, is again elevated back to the group of Gyrex screens by conveyor belt and the oversize again goes to the rolls. The treating of non-cupreous ore is similar, except that the +2½ in. from the Niagara screens goes to the Symons cone crusher, and the +1½ in. -2½ in. goes to storage as furnace size for export, or to the Symons for crushing to fines. This unit, with a capacity of 2,200 tons/8-hr. shift, produces four products, lumps for smelter, furnace size, and cupreous and non-cupreous fines.

No. 1 unit, used in the treatment of washed ore, has a capacity of 1,200 tons/8-hr. shift. Washed ore is made at Rio Tinto by leaching. Cupreous pyrites is subjected to alternating periods of oxidation and lixiviation, the copper coming out in solution as copper sulphate. Washed pyrites contains about 48% S and 0.25 to 0.35% Cu. 'Run-of-mine' massive pyrites, passing a 9-in. grizzly, is then tipped on non-porous solid ground into 50,000- to 100,000-ton heaps, 7 m. high. By building a false bottom under the ore, free ventilation is provided for the oxidation process. The heap is then systematically sprayed with acid mine liquor. It takes from 2½ to 3 years to reduce the copper content of the ore down to 0.3%.

## Pyrites from low-grade ores

A plant is being built which will treat low-grade ore, accumulated to the extent of several million tons over the past 60 years. It is designed to handle 300,000 tons p.a. and produce about 220,000 tons of pyrites. It will consist of a combination of heavy medium separation, Wilfley table concentration, and flotation applied to various sized ores. Heavy medium operation depends on the principle of normal gravity separation of sized particles conducted in a medium artificially made to a certain specific gravity. At the Rio Tinto plant it will be made from ferro-silicon suspended in water. Test work showed that at 10 mesh and with a medium of 2.94 specific gravity excellent separation is obtained. It is expected that this section, together with the Wilfley tables and flotation units, will recover more than 90% of the pyrites in their respective feeds and

that their product will not contain less than 48% sulphur.

## By-product pyrites as flotation concentrates

At the St. Joseph Lead Co., the recovery of by-product pyrites as flotation concentrates is carried out. The mine and mill described is at Balmat, New York State.

In the recovery of a pyrites concentrate from an ore which is being mined primarily for its lead and zinc content the 11-in. ore lumps are reduced in the coarse crushing section to -3 in. and then to 100% -½ in., at which size it is fed to the rod mills. From these two rod mills the product is fed to a Forrester flotation machine which recovers a coarse rough lead concentrate having a sizing analysis of 10% +48 mesh, 40% -200 mesh. The tailings are then ground in an Allis Chalmers ball mill to 48.6% -200 mesh, achieving a fineness at which the valuable mineral is almost completely liberated from the gangue. The pulp flows directly to the Forrester machine. For the lead flotation, Aerofloat No. 31 (0.07 lb./ton), sodium xanthate (0.02 lb./ton) and sodium cyanide (0.05 lb./ton) are added. The rough lead concentrate is cleaned in a series of cleaner cells, and a marketable lead concentrate is produced. The tailings from the Forrester pneumatic cell pass to conditioners where 1.2 lb. of copper sulphate per ton are added to reactivate the sphalerite (the principal zinc mineral), 1 lb./ton of lime as a depressant for the pyrites and 0.35 lb./ton of pine oil as a frother; 0.08 lb./ton of sodium Aerofloat is then added as a sphalerite collector.

In the case of zinc, the tailings from the zinc circuit pneumatic cells go to the pyrites recovery circuit and from there to conditioners in which 0.23 lb./ton of sodium ethyl xanthate is added with pine oil as a frother. The pulp passes to a bank of Forrester cells which makes a rougher concentrate which is cleaned in mechanical cells and rejects a final tailing to dump. Pyrites concentrates from the cleaner cells are reground in a Denver ball mill to 54% -200 and, after conditioning with lime, copper sulphate, xanthate and pine oil, they are treated in mechanical-type cells which produce a rougher zinc concentrate, so that the tailings from these last cells are the finished pyrites concentrate. The pyrites concentrates pulp, containing 16% solids, is passed to two Dorrclones in series, the underflow from the Dorrclones containing 45% solids. After filtration of the underflow, a cake containing 9% moisture is produced, which is dried to about 2% moisture. The final analysis of the pyrites concentrates after recleaning for the recovery of residual zinc is: Fe, 43%; S, 49.44%; Zn, 1.39%; Pb, 0.18%.



# Rates of Drying in Tray and Rotary Driers\*

By J. P. Duffy, B.Sc.

The process of drying originated as an art and developed into a science. With the evolution of drying machinery there appeared an extensive variety of designs ranging from primitive appliances to those incorporating modern principles of scientific development. The many industrial applications of the process have given rise to different types of drying plant, each designed to accommodate a particular group of raw materials. How is one to assess the relative merits of the different types of drying machinery? The question is simplified by confining attention to the drying of materials in tray and rotary driers. The efficiency of a drier may be judged on the basis of the rate of drying, since the function of a drier is specifically to facilitate the removal of unwanted moisture by thermal evaporation. In general, the rate of drying is a complex function of the physical properties of the material being dried and of the operating variables predetermined by the type of drier and the state of the drying medium.

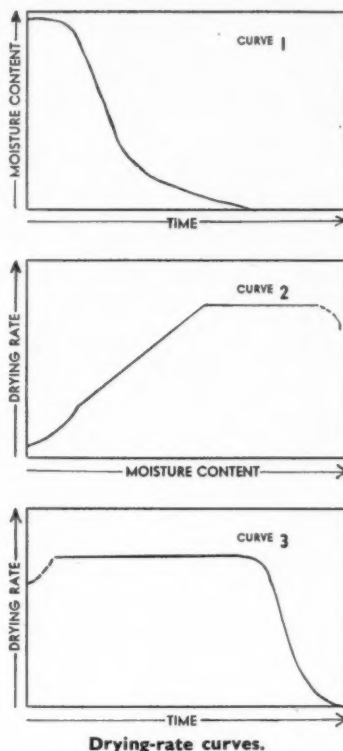
THE development of the Classical Theory of drying has done much to explain the mechanism of the drying process. The fundamental concepts involved are heat and mass transfer, and diffusion. The process is divided into three phases: the constant rate period of drying, during which surface evaporation is predominant; the primary falling rate period, during which surface evaporation steadily decreases; and finally the secondary falling rate period in which evaporation is assumed to occur mainly within the solid.

## The constant rate period

Water vaporises from a *very wet* solid into air very much as it evaporates from a free water surface. The phenomenon here is one of diffusion, the diffusional resistances being in the air film adjoining the liquid surface. The structure of such films is not perfectly understood, but it is believed that the diffusional resistance encountered is the sum of the resistance of a surface laminar layer through which moisture is transferred by molecular diffusion, and the resistance of an eddy region in which the transfer is by eddy motion or mixing. So long as the surface of the solid remains wet with water the rate of vaporisation is constant and the factors affecting the rate of drying are similar to those affecting the evaporation of water from a free liquid surface. Since the surface may remain wet, and the rate of vaporisation constant, over a large range of moisture contents, this part of the drying process has been called the constant rate period. During this period the solid assumes nearly the wet-bulb temperature of the air.

## The falling rate period

Eventually there comes a period when the wetted area of the solid begins to diminish and the surface begins to appear quite dry. At this point it is not possible to determine by visual observation whether or not vaporisation is occurring at the surface. This transition point in the



Drying-rate curves.

mechanism of drying, where the constant rate ends and the drying rate begins to fall, marks the critical moisture content of the solid and indicates the commencement of the primary falling rate period. At this point the moisture content of the solid has diminished to such an extent that the power of the solid to deliver moisture to the surface has become less than the power of the air to evaporate such water. This causes the plane of evaporation to retreat into the solid. The distance to which this plane of vaporisation will move in a given time will depend upon a number of factors, such as the rate of liquid moisture movement within the solid, the rate of water vapour diffusion through that part of the solid between the internal plane of vaporisation and the surface, and the rate of

heat transfer through these same zones. The plane of vaporisation will continue to move into the solid until all the free moisture has been removed. Finally all the forces associated with the process reach their equilibrium state and the now dried material has reached its equilibrium moisture content, which limits the amount of moisture a material can hold under specific conditions of air temperature and humidity.

## Drying rate curves

When a solid is dried experimentally, data are usually obtained relating the moisture content to the time of drying. These data are plotted graphically as moisture content against time of drying. Curve 1 represents the general case when a solid loses moisture first by evaporation from a free water surface on the solid, followed in turn by a period of evaporation from a free water surface of gradually decreasing area and, finally, by evaporation of water in the interior of the solid.

The drying curves of moisture content plotted against time look very much alike no matter what the mechanism of drying, but when these curves are differentiated and a plot prepared showing the rate of drying as a function of moisture content, there will be an indication of discontinuity at the points where the mechanism changes.

Various types of rate curves may be obtained for different materials depending upon the physical structure of the material and upon the manner in which moisture is associated with it.

## Moisture movement within solids

Moisture may be present as hygroscopic moisture, water of crystallisation, surface moisture or absorbed water.

During drying, liquid water tends to move from the interior to the surface of the solid where the concentration is lower. This movement is loosely termed 'diffusion,' but water will flow from a low concentration region to one of high concentration when the right conditions of pore space exist. In fact, capillary forces and not diffusional forces are probably the

\*Reproduced, by permission, from *The Birmingham University Chemical Engineer*, 1952, 4, (1).

controlling factor. The mechanism of capillary movement of liquid water through a solid which is undergoing drying is well illustrated by a simple experiment: A glass tube is drawn out to form a tapered capillary several centimetres in length. It is filled with water and allowed to remain exposed to the air. During drying the small meniscus remains stationary at the small end of the tube, while the large meniscus moves progressively from the large to the smaller end until evaporation is complete.

Despite its invalidity, it has become common practice to employ the diffusion law in calculating the rate of moisture movement within a solid during drying. The application of diffusion equations to drying problems was the result of a belief that moisture movements in solids were analogous to heat conduction in solids. The diffusion equations have been based on Fick's Law,<sup>3</sup> which states that the quantity of material diffusing per unit time is proportional to the area and to the concentration gradient in the direction of diffusion.

The apparent success of these equations for the calculations of drying times for such substances as wood and clay lies in the fact that these calculations are made by integration methods that compensate for the errors caused by assuming wrong moisture distributions.

#### The attainment of equilibrium

When the heat necessary for evaporation in the constant rate period is supplied by a hot gas, a dynamic equilibrium is established between the rate of heat transfer to the material and the rate of vapour removal from the surface. This equilibrium between heat and mass transfer rates can be expressed in the form of a differential equation:<sup>5</sup>

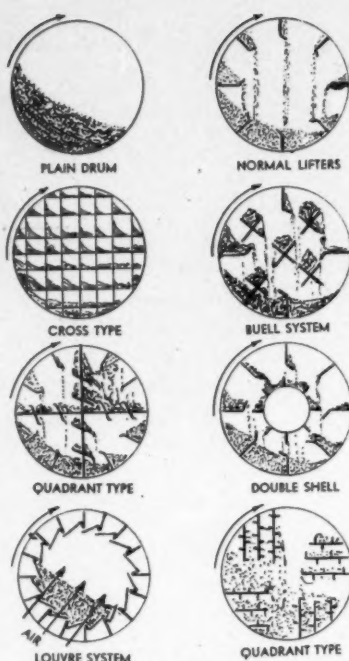
$$\frac{dW}{d\theta} = \frac{h_t A \Delta t}{\lambda} = k_g A \Delta p \dots \dots (1)$$

Equation (1) indicates that the constant rate depends upon three factors: (a) the heat or mass transfer coefficients; (b) the effective area exposed to the drying medium; and (c) the difference in temperature or humidity between the air stream and the wet surface of the solid.

Air velocity is the most important factor affecting the rate of drying in the constant rate period.<sup>5</sup>

During the primary falling rate period the mechanism of drying is essentially the same as that operating in the constant rate period, but at this stage portions of the solid surface begin to appear dry and protrude into the air film. Consequently, the rate of evaporation per unit area of apparent surface is reduced.

During the secondary falling rate period the mechanism of internal liquid flow controls the rate of drying. When a wet solid is being dried to very low moisture content this period predominates in deciding the time required for drying.



Cross-sections of various types of rotary drum driers.

Studies of internal moisture flow have indicated the possibility of several controlling mechanisms, the more significant ones being diffusion, capillarity, and pressure gradients due to shrinkage of the material.

The rate of drying during this period is no longer affected by air velocity; the temperature of the solid rises and finally approaches the temperature of the moving air stream. The rate of drying approaches zero as the entire solid becomes 'dry.' The diffusion equations are applied to this period. The diffusivity is, however, rarely constant and will vary with moisture content, temperature and humidity. Van Arsdell<sup>1</sup> has developed a graphical method of determining the variation of diffusivity with moisture content.

During the constant rate period the average temperature difference is constant, but during the falling rate period it decreases gradually and in a manner not yet susceptible to theoretical analysis. The drying time for the falling rate period is summarised in two equations, one based on the assumption that the diffusivity is constant and the other assuming that the diffusivity is proportional to thickness.<sup>5</sup>

#### Estimate of the overall drying rate

For a given drying problem, an estimate of the overall drying time involves a summation of both the constant rate period and the falling rate periods. For the case of tray driers appropriate empirical equations have been developed to predict the overall drying time. Equations are available in the literature<sup>6</sup> referring to cross-circulation drying, when hot air is blown over the surface of the wet material, and to through-

circulation drying, when hot air is blown through a bed of the material.

#### Application of drying theory to rotary driers

The concepts of constant rate and falling rate periods, diffusion mechanism and capillary action are rather definitely related to the study of drying in tray driers, and have a more obvious application to these types than to rotary driers. However, the approach to the problem of measuring drying rates in rotary driers may be made by the use of heat transfer equations suitably modified to include the factors influencing the drying operation.

#### Time of residence

The first point in the study of the operation of a rotary drier is the residence time of the wet material within the drier. Generally speaking, there are four types of rotary drier in current use, all of which consist essentially of a rotating drum slightly inclined to the horizontal, supported on roller paths and driven mechanically by means of a girth wheel and pinion. The four types may be described as single shell, double shell, cross and louvre. They have been designed to permit the continuous processing of wet material and differ only in the method of applying heat and the amount of material and surface exposed to the action of the hot drying gases. The choice between these types is usually dictated by the necessity to protect the wet material from excessive heat or rough handling.

The residence time decides the degree of moisture removal under a given set of drying conditions. In considering the action of a direct single-shell rotary drier in which the warm air is passing counter-current to the wet material it will be assumed that the moisture resides on the surface of the individual particles. The cylinder of the drier is fitted with internal flights or shelves. As the cylinder rotates, these flights pick up the material and cascade it in thin streams or curtains, parallel to one another and extending throughout the portion of the drier so fitted. For the most part, the warm air flows through the cylinder in direct contact with the moist surface of the material granules on either side of each curtain. During rotation, the falling curtains appear to the observer to pass from one side of the cylinder to the other. The progress of the charge through the rotary drier is influenced by nine factors, namely (i) percentage loading or feed rate, (ii) number of flights, (iii) design of flights, (iv) slope of the drier, (v) rotational speed of the drum, (vi) length of the drum, (vii) diameter of the drier, (viii) physical properties of the charge and (ix) velocity of the warm air through the drier.

The factors influencing residence time in rotary driers are summarised in an empirical equation put forward by Prutton, Miller and Schuette:<sup>8</sup>

$$T = \frac{kL}{RDS} \pm mV \dots\dots\dots(2)$$

The time of passage of the material in the drier is defined as hold-up divided by feed rate. It can be measured directly if such information is available, otherwise recourse may be had to the empirical equation given above.

#### Air velocity

It is customary to employ the highest air velocity possible without serious dusting. The amount of dusting occurring during operation is a complex function of the type of material being dried, its physical state, the air velocity employed, the hold-up in the drier, the number of flights, the rate of rotation and the construction of the breeching at the end of the drier. It can only be found experimentally. An air rate of 1,000 lb./sq.ft. hr. can usually be safely used with 35-mesh solids.

#### Heat transfer in the rotary driers

Drying in a direct single-shell rotary drier is best expressed as a heat transfer mechanism. As pointed out by Walker, Lewis and McAdams,<sup>7</sup> heat exchange in a rotary drier is an equilibrium reaction and may be represented by the usual heat or mass transfer equations. In practice the total heat transferred from the air stream to the wet charge is measured by means of the overall heat transfer equation:

$$\frac{Q}{\theta} = UA \Delta t_m \dots\dots\dots(3)$$

The area  $A$  involved in the above heat transfer equation may be considered as being the effective areas of the individual particles which fall through the air stream in unit time. Since it cannot be at all easily measured, recourse is had to an alternative method of writing the heat transfer equation:

$$\frac{Q}{\theta} = U_a V \Delta t_m \dots\dots\dots(4)$$

Friedman and Marshall<sup>8</sup> give data for the evaluation of the term  $U$ :

$$U_a = \frac{10 G^{.16}}{D}$$

#### Estimation of the overall drying time in rotary driers

The estimation of drying rates in rotary driers may be made by the use of modified heat transfer equations. If equation (4) is modified to include the latent heat of evaporation of water the resulting expression will give the rate of drying in terms of lb. of water evaporated per cu. ft. of drier volume:

$$\frac{Q}{V\theta\lambda} = \frac{U_a \Delta t_m}{\lambda} = \frac{W}{V\theta} \dots\dots\dots(5)$$

Equation (5) does not express the drying rate in terms of effective heat transfer surface area, but only in terms of volume. Thus it is not possible to correlate drying

#### NOMENCLATURE

$A$	area of heat transfer and evaporation (sq. ft.)
$D$	diameter of the drier (ft.)
$D'$	average height of falling curtains (ft.)
$G$	mass velocity of air (lb./sq.ft.)
$h_t$	heat transfer coefficient (B.Th.U./sq.ft. hr. °F.)
$k$	a constant which is dependent upon the number of flights and their design. Range of values 3.3 to 4.5
$k_g$	mass transfer coefficient (lb. water/sq.ft. hr. atm.)
$L$	length of the drier (ft.)
$m$	a constant dependent upon: (a) type of material being dried and (b) the method of operating the drier. $m$ is the slope of the retention time—air velocity curve. It is positive for counter-current flow and negative for parallel flow. Values range from 0.015 to 0.08
$N_f$	the number of flights actively generating the falling curtains at any instant
$Q$	total heat transferred from air stream to wet material (B.Th.U.)
$R$	rate of rotation of drier (r.p.m.)
$r_f$	the radial height of a flight (ft.)
$S$	slope of the drier cylinder (in./ft.)
$T$	residence time (mins.)
$U$	overall heat transfer coefficient (B.Th.U./sq.ft. hr. °F.)
$U_a$	overall volumetric heat transfer coefficient (B.Th.U./cu.ft. hr. °F.)
$V$	volume of drier (cu. ft.)
$W$	water evaporated (lb.)
$x$	a power
$\Delta p$	difference between vapour pressure of water at the surface of drying and the partial pressure of water vapour in the drying medium (air) (atm.)
$\Delta t$	difference between temperature of the drying medium (air) and the temperature of the surface of evaporation (°F.)
$\Delta t_m$	the average thermal driving force, arbitrarily taken as the log mean temperature difference based on the difference at the end of the drier (°F.)
$\lambda$	latent heat of evaporation of water (B.Th.U./lb.)
$\theta$	time of drying (hr.)
$\frac{dW}{d\theta}$	drying rate (lb./hr.)

rates in rotary driers with those in tray driers, since the latter have a capacity which is measured primarily in terms of surface area, whereas the rotary drier has a capacity measured in terms of drier volume. To overcome this difficulty Prutton, *et al.*,<sup>9</sup> have proposed the following type of equation, in which the main variables affecting drying rates in rotary driers have been included:

$$\frac{W}{\theta} = \frac{Q}{\theta\lambda} = \frac{ULD' r_f N_f G \Delta t_m}{\lambda} \dots\dots(6)$$

#### Commercial data

Only a very limited amount of performance data has been published. For the case of tray and compartment driers an overall evaporation rate of from 0.03 to 0.3 lb. water/sq.ft. hr. based on tray surface area is indicated. For the case of batch through-circulation drying, evapora-

tion rates of from 0.3 to 2.5 lb. water/sq.ft. hr. of loading surface have been reported. For continuous through-circulation drying, the rates may range from 0.26 to 7.8 lb. water/sq.ft. hr.<sup>5</sup>

Drying rates in rotary driers are expressed on a volume basis. Gas-, oil- or coal-fired, direct-heated rotary driers will evaporate from 2 to 7 lb. water/cu.ft. of drier volume. If steam-heated air is used the rate will range from 0.2 to 2.0 lb. water/cu.ft. of drier volume.<sup>5</sup>

The rotary drier has an efficiency which, if measured in terms of drying rate, is greater than that of the tray drier. The rotary type will promote the rapid drying of wet granules because each particle is exposed to the action of the hot gases, whereas the tray drier offers only a limited fraction of the available reaction surface.

#### Importance of the physical characteristics of materials

Despite the obvious superiority of the rotary drier over the tray drier there are certain kinds of materials which are very difficult to dry by reason of the extraordinarily high internal resistance to moisture flow encountered. The problem then becomes not one of heat transfer but rather one of controlling the drying conditions so that the movement of moisture to the surface of the material is not hindered by the creation of additional surface resistances.

As an illustration of this kind of problem one may refer to the work of Van Krevelin and Hoftijzer on the drying rate of granules containing a soluble salt.<sup>4</sup> Granules of Nitro-Chalk fertiliser (60% ammonium nitrate and 40% marl) were dried by two methods: (a) suspended in a stream of hot air and (b) in a rotary drier. It was found that the drying rate was the same in each case and was of the low value of 0.023 lb. water/sq.ft. hr. based on material drying surface. Furthermore, it was found that the measured drying rate was 1,500 times smaller than that calculated for the case where only mass transfer through the gas film would have been the determining factor. It was therefore assumed that the following mechanism was operative: in the beginning, drying took place at the external surface, saturated ammonium nitrate solution being supplied from the interior of the granule. During evaporation of the water, ammonium nitrate crystallised. Gradually the pores through which the solution could flow to the surface became obstructed by a crystal film of ammonium nitrate and the rate of drying decreased. Finally all the pores became closed up and the supply of solution stopped. In the whole granule the temperature of the air prevailed so that the vapour pressure remained constant. Then drying took place by means of water vapour diffusion through the crystal film. For this particular type of material the rate of drying is independent of the air velocity

(Concluded on page 62)



# PLANT MAINTENANCE TECHNIQUES

A comprehensive code of plant maintenance is laid down in a new British Productivity Report 'Plant Maintenance,'\* written by a team which visited the U.S. last year to study maintenance in many industries, including chemicals, oil-refining, brewing and paper-making. It is pointed out that a new outlook towards maintenance has developed on both sides of the Atlantic. This is preventive maintenance and the team urge that this attitude of mind should spread throughout industry. Below we present a complete chapter from the report; it deals with maintenance techniques and design for maintenance.

**I**N plants where maintenance techniques were good, it was evident that careful planning and the adequate provision of labour-saving tools and transportation were effectively employed by management in attacking idle time. Complementary to this approach by management, it was particularly noticeable that operators exhibited a high degree of skill and dexterity in handling mobile equipment and tools.

## Maintenance techniques

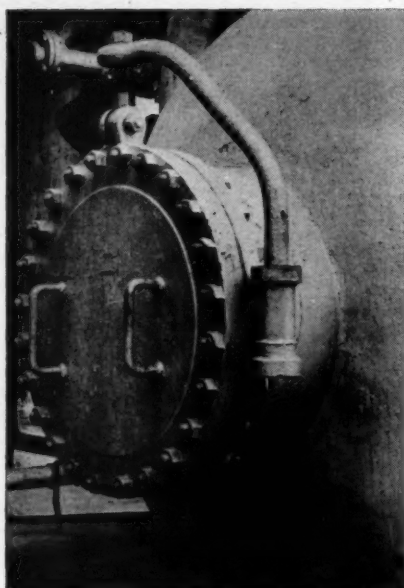
*Chemical cleaning* of plant is a development yielding important savings of man-hours when applied to such equipment as boilers, heat-exchangers, condensers and other plant, which normally requires opening up for cleaning by manual labour. This type of work is usually undertaken by a contracting firm which specialises in the particular cleaning method required, and brings to the site mobile solvent cleaning apparatus.

*Mechanical scaling* has been developed along lines similar to techniques employed in the U.K., and in the examples seen the conventional air motor and flexible drive were used.

*Sand or shot blasting* has been developed in some instances to a point where it can be effectively used as a substitute for the rather lengthier operation of mechanical scaling with air motor-driven tools. Sand blasting is being used successfully for de-scaling the inside and outside of condenser tubes, and even for the internal scaling of 'U' type condenser tubes.

*Mobile equipment* provides some of the best examples of time-saving techniques exhibited by U.S. operators. Some typical examples were:

- (i) Straddle trucks, originally developed for handling timber, have now been adapted for the transportation of almost any type of heavy load of awkward shape. They are designed with a road clearance of about 6 ft., and have an opening between the road wheels of about 5 ft. Their load-carrying capacity is of the order of 20 tons, and hydraulic lifting equipment is provided between the wheels. The method of using these straddle trucks is,



A built-in davit for holding heavy doors. After removing bolts, the door can be swung clear to allow access to vessel.

- generally, to drive over the load to be lifted, 'straddling' it, raise it a foot or two off the ground and move it to the new location.
- (ii) Motor scooters are provided for the use of foremen and supervisors, and often for craftsmen also. In this event the scooter is usually fitted with a toolbox.
- (iii) Fork trucks are used with remarkable ingenuity, having special attachments such as fitments for picking up barrels without the use of pallets.
- (iv) Mobile cranes, quite apart from their conventional use, are frequently employed for carrying out work in some elevated location, which otherwise would necessitate scaffolding.
- (v) Mobile toolboxes are combined with small vice-benches, the whole being mounted on a steel chassis fitted with pneumatic-tyred wheels.
- (vi) Power-driven wheelbarrows are another labour-saving device frequently seen in use.

*Two-way radio communication* has been developed as a means of keeping in contact with mobile equipment while in service, within a radius of about five miles. Instruc-

tions from maintenance foremen, passed through a central despatch office, enable the operators of mobile equipment such as cranes, trucks, etc., to make much more efficient use of their time.

*Impact wrenches* are now available for removing and tightening nuts from as small as  $\frac{1}{4}$  in. up to 3 in. diameter studs and bolts. In the larger sizes a tool of this nature enables two men to do the work of six. Moreover, it can be used effectively in a confined space.

*Portable pipe-threading machines*, electrically driven from the lighting supply, enable craftsmen to turn out better work in less time.

*Lubrication* as a maintenance technique was in two or three instances reduced to a well-planned routine. A survey of the plant, usually by some independent authority, is first made, and the total number of types of lubricant employed reduced to the minimum. A simple visual code, combining geometrical figures with different colours, enables every point of lubrication on a machine to be precisely identified with the type of lubricant to be used and the frequency of application.

The operative responsible for lubrication is provided with a trolley, sometimes power-driven, on which are mounted suitable containers of lubricants and greases under pressure and, provided he follows the code provided, every machine is correctly lubricated at the right time. A record card attached to the machine is filled in at the time of lubrication. A lubrication engineer is sometimes employed where the size of a works renders this desirable.

*Pneumatic tools* give long, trouble-free service, provided the supply of air is dried and line lubricators are installed so as to enable a small amount of oil to be carried along with the air to the tool.

*Reclamation of worn parts* instead of replacement is now more frequent in the U.S. than it used to be. Conventional methods of metal-spraying and building-up by welding are employed. In two or three instances, by careful choice of the type of electrode, better service was obtained from the worn part than it gave when new. This is a field where the employment of a metallurgist, or the use of a works laboratory, is often justifiable.

*Pipe trenching* on a small scale, performed by a small machine mounted on a jeep,

\*Copies of the Report (price 2s. 6d. post free, excluding air mail) can be obtained from the British Productivity Council, 21 Tophill Street, London, S.W.1.

becomes economical in congested areas.

**Horizontal earth boring** by means of a power-driven machine results in substantial savings in man-power when laying pipes under roads or through embankments.

### Design for maintenance

A few of the plants visited were new or had recently completed new extensions. In some the layout and design gave proof of co-operation between maintenance engineers and the designers. The following are typical examples that were seen of good design for maintenance.

**Access** for mobile equipment, including adequate overhead clearances.

**Cathodic protection** is now generally accepted as an economic way of safeguarding buried steelwork and pipelines.

**Synthetic plastics** are put to many ingenious uses for protecting equipment, such as coating the cutting edges of machine tools while they are lying in store. The protective coating is readily peeled off just before the tool is used.

Another example is the use of liquid neoprene, either brush or spray applied, which, after hardening, forms an effective protection for internal steel surfaces against corrosion, in tanks for instance.

**Gunit** linings are still popular in the U.S. for the protection of internal surfaces of tanks and vessels holding corrosive fluids.

**Mastic coatings**, consisting of granulated cork, mica flake or asbestos, with an asphaltic bitumen as binder, have been found more successful than paint for protecting steelwork exposed to unusually severe atmospheric corrosive conditions. This treatment has been found particularly successful in chemical plants near the sea coast, and in the case of equipment to leeward of cooling towers.

**Wear plates**, sometimes of steel, sometimes of reinforced concrete, are widely used where erosive conditions prevail, and where they may conveniently be located.

**Dust removal** is recognised as an important contribution to the reduction of wear in moving machinery, and some very efficient examples of vacuum air-ducting were seen for the removal of carborundum and other abrasive dust. Considerable attention is paid to sealing bearings for the exclusion of dust.

**Ventilation**, sometimes combined with air-conditioning, is used extensively in the U.S. as a means of improving working conditions, both for men and machines.

**De-aeration** is more commonly employed in the U.S. than in the U.K. as a means of preventing corrosion in water-cooled equipment.

**Artificial lighting** is usually designed with a higher intensity of illumination, of the order of 25-ft. candles at the working surface, than is commonly met elsewhere. Efficient lighting at all times is given considerable prominence in American factories, and is doubtless an important factor in the reduction of maintenance work.



An impact wrench in use

With regard to the question of fluorescent light *versus* tungsten filament lighting, there is a tendency in the U.S. to employ a combination of both in the same room. Sometimes the two are combined in one fitting.

In locations where the replacement of a lamp might interfere with production, routine replacements are made during shut-down periods, irrespective of whether a lamp has failed or not. Such lamps, after removal, are used somewhere else where the act of replacement does not interfere with production.

**Mechanical handling** is built in as much as possible in laying out a new plant, and it is usually found that simplicity gives the best results. Chief among typical examples were:

- (i) Davits, fitted over inspection covers weighing more than, say, 50 lb., considerably simplify their removal and replacement, and avoid damage to gaskets.
- (ii) Steel runways, strategically located when a plant is first built, enable the maximum use to be made of standard lifting blocks when plant has to be serviced later.
- (iii) Wall cranes of the swinging cantilever type are used where the simpler

davit or runway principle is inadequate.

Perhaps one of the most fruitful fields of investigation in designing for maintenance is to ensure that the maximum benefit is obtained from past experience, and to eliminate known weaknesses. As examples, the following are cited:

- (a) Eliminate flanged joints wherever possible and substitute with welding. This is particularly applicable to joints inside vessels, such as cooling or heating coils.
- (b) Reduce maintenance of pump glands by the use of mechanical seals where applicable.
- (c) Employ pneumatic handling of corrosive liquids as a substitute for pumps where pressures are low enough.
- (d) Simplify the spare-part question by the maximum degree of standardisation.
- (e) Simplify machinery guards so that they may be easily removed for inspection and servicing plant.
- (f) Where individual pieces of equipment are known beforehand to require occasional movement to a central workshop for servicing, provide adequate means for lifting; also provide a sound method of locating when refitting or re-aligning.

### Reduction of maintenance by process control

An important use of maintenance record cards is for tracking down persistent excessive maintenance, and investigating whether it is related to unnecessarily arduous conditions of operation.

Persistent failure of a piece of equipment may be the fault of the operation rather than the unsuitability of the equipment itself, or its method of use, and the trouble can frequently be corrected by a minor adjustment to the process.

In the last few years one of the most effective developments in controlling process conditions with the object of reducing maintenance effort has been through improved instrumentation.

**Instrumentation** can be made to ensure that a plant operates under constant controlled conditions of pressure, temperature and rates of flow, which alone go a long way to reduce operational upsets and hence maintenance effort.

Corrosion can be very much reduced or entirely eliminated by the employment of instruments for the automatic control of the pH value of certain critical streams within a plant.

To get the maximum benefit from instruments they must, of course, be kept in perfect working condition and, to simplify their maintenance, adequate working space must be provided behind the instrument panel, and they should be operated with dried air.

The plant having been provided with

steady running conditions, there remains considerable scope for ingenuity in planning for minimum overall maintenance by making a careful analysis of the plant operation itself. This can best be explained by a number of examples:

- (i) *Power failure*, apart from its immediate effect on a plant, can cause secondary troubles unless these are guarded against. Provided the study has been made beforehand, secondary damage can be prevented and the effect of a power failure limited. The same remarks apply to steam failure, water failure, etc.
- (ii) *Feedstock failure*, similarly, can cause secondary damage in a plant, quite apart from the more obvious result of temporarily shutting it down. Adequate planning can eliminate such secondary damage.
- (iii) *Thermal expansion and contraction*, a frequent cause of maintenance effort, can frequently be eliminated by keeping a line or other piece of equipment hot, even though it may be temporarily taken out of service.

In general, to reduce maintenance effort through process control, the principle should be followed, firstly, of achieving the maximum degree of simplicity within the plant itself by eliminating all unnecessary equipment; and, secondly, of being continually watchful of possible upsetting influences and their secondary effects.

## Conclusions

(i) In the general approach to maintenance techniques it appeared to the team that American methods are based, to a certain extent, upon a freer availability of spare parts and labour-saving equipment than there would be in the U.K. There is, however, a tendency for spare parts and replacement materials generally to be less readily available now than they were formerly, and this appears to be bringing about the introduction of maintenance techniques aimed at preserving and repairing equipment rather than replacing it.

(ii) It appeared to the team that those responsible for maintenance in America exhibited, to a marked degree, a tendency to examine critically their own methods with a view to their constant improvement.

(iii) There was evidence of a growing recognition of the value of discussion between management and the production and maintenance sections of a works, and also of the value of interchange of views on maintenance techniques between different plants of the same company, as well as between different industries.

## Recommendations

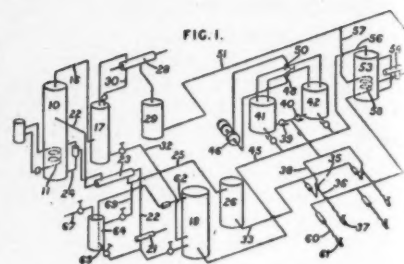
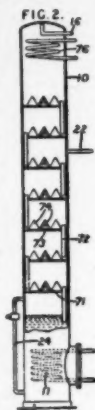
(i) That industrial managements and engineering staffs in the U.K. should satisfy themselves that the maximum benefit is being obtained from capital invested in labour-saving tools and equipment from two points of view:

# Chemical Engineering Invention

## MONTHLY SUMMARY OF PATENT CLAIMS

### Distilling ammoniacal solutions

The process, in a stationary plant for separating ammonia from a strong aqueous solution formed in the absorbent holder of a mobile refrigerated container as described in Specification 639,271 (Group XIII), is as follows. Strong solution is introduced into a tower 10 (Fig. 2) through a tube 22 and falls through bubble-trays 71. Here it is met by water vapour rising from the foot of the tower heated by a coil 11. The ammonia is thus distilled out of the strong solution. The ammonia vapour is led by a pipe 16 to the bottom of a similarly constructed rectifying tower 17 down which flows condensed ammonia. The rectified ammonia then proceeds to a condenser 28, from which part flows back to the rectifying tower and part flows to a storage tank 29. The bubble trays are pierced by several short pipes 73 having perforated conical hoods 74. Vertical fall pipes 72 feed liquid down the tower from tray to tray. Weak and strong solutions are withdrawn from the bottom of the distilling and rectifying towers respectively and the top of the tower 10 is fitted with a cooling coil 76. Connections 37 (Fig. 1) are connected to the absorbent holder on the mobile container and strong solution flows by a pipe 36, three-way valve 35 and pipe 38 to check-valves 39, 40, controlling the input to tanks 41, 42, which are connected by linked three-way valves 48, 50, to a pump 46. The pump 46 sucks



solution into one of the tanks 41, 42, and discharges solution from the other through a pipe 45 to a storage tank 18 from which solution is pumped by a pump 21 through a heat-exchanger 23 and a pipe 22 to the tower 10. In the distilling tower, ammonia is driven off and passes through the rectifier 17 to the condenser 28, from which it flows to the storage tank 29. Water drains from the tower 10 by pipe 24, heat exchanger 23 and pipe 25 to a storage tank 26. The rectifier 17 is fed with condensate by a pipe 30 and drains to the tank 18 by a pipe 32. Non-condensable gases are removed from the tank 18 by a pipe 62 to a tank 64 where they are washed by water from the tower 10 entering by pipe 69 and leaving by pipe 65, the gases being shifted through pipe 67. To charge a mobile container with anhydrous ammonia and water, connections 37 are connected to the absorbent holder and hoses 61 to the refrigerant holder. Refrigerant, i.e. ammonia, flows from the storage tank 29 by pipe 51, precooling coil 58 and pipe 57 to the connections 61, some refrigerant being by-passed through a float control 54 to cool the coil 58 in a chamber 53, vapour being returned to the tank 18 by pipes 56, 45.

Absorbent, i.e. water, flows from the storage tank 26 by pipe 33, three-way valve 35 and pipes 36 to the connections 37.—641,000, *Standard Cap & Seal Corporation*.

### Synthetic ammonia

Ammonia is prepared by passing hydrogen and nitrogen over a catalyst containing at least one metal from the iron group and at least one of the metals magnesium and vanadium at a temperature not greater than 450°C.

The specification as open to inspection under Section 91 comprises also the combination with the metal from the iron group of at least one metal capable of forming a nitride at the temperature of reaction. This subject-matter does not appear in the specification as accepted.

Reference has been directed by the Comptroller to Specification 609,756.—640,170, *S. O. B. Odelhog*.



# Plant and Equipment

## Vibratory feeder

An electric vibratory feeder has been produced to handle powders and granular material at the rate of a few pounds to 10 tons/hr. It is claimed to give an infinitely variable feed over a wide range of quantities, but at a given setting the feed is constant, enabling grinding mills, crushers, packing machines, sifters, mixers, etc., to be used at a maximum output. This even feed often enables an existing machine which is being hand fed to give a greater output, or when installing new plant enables a smaller machine to do the same job. The feeder can be arranged for automatic operation to control the level of material in a hopper, to feed a pre-determined weight of material, or to operate during a given time cycle.

The high-frequency vibration is applied directly to the chute by means of a powerful electro-magnetic unit. The absence of wearing parts, belts, gears, bearings, eccentrics or striking parts ensures reliable service over long periods without greasing or maintenance. The feeder can convey material for short distances to avoid the complication of additional plant and economise in the space required. It will handle materials which do not normally flow freely. In these cases, however, a bin vibrator is usually advisable to prevent the material arching or sticking in the feed hopper. Manufacturers of the machine are Podmores (Engineers) Ltd.

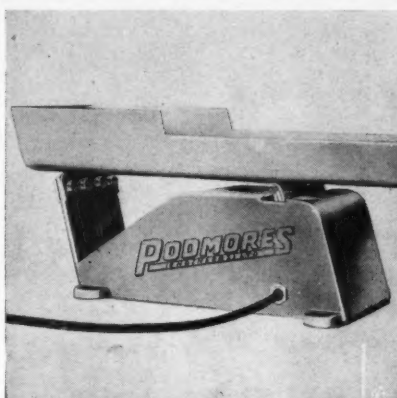
## Mixer and emulsifier

What is claimed to be an improved method of mixing and emulsifying liquids has been devised by the Sinex Engineering Co. Ltd., who term it 'vibro-agitation.' This energy is applied to the material by a countersunk perforated disc attached to a hollow shaft suspended from the vibrating head. The hollow shaft permits the introduction of gases to the liquid in the tank, the gas being atomised by the vibration.

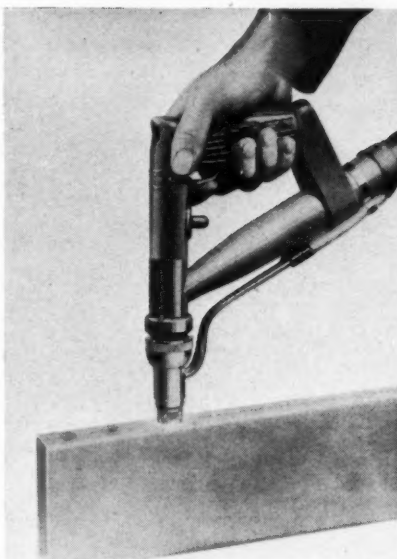
The drilling and countersinking of the disc determines the type of transmission and the effect of the vibrator on the medium. Generally speaking,  $\frac{3}{16}$  in. drilling countersunk to  $\frac{1}{2}$  in. diameter seems to give the best results. Various transmitters of different materials can be supplied to suit particular applications, and these are quickly and easily changed.

Four models are supplied with capacities of 5, 60, 400 and 750 gal. respectively. The smallest model, S.E.I., has been designed for laboratory use for test purposes. Three larger production models are supplied for general industrial use, but it is emphasised that each vibro-agitator should be tailor-made for the job, and that the small model should be used first to determine actual working conditions.

The vibrating head of the smallest unit



High-frequency vibratory feeder.



'Argonarc' spot-welding torch.



Laboratory unit for mixing liquids by 'vibro-agitation.'

is mounted on a standard shaft of  $\frac{1}{2}$  in. diameter, attached to a small supporting stand. Its position can be adjusted by sliding and/or rotating it on the shaft. The head is held in position by a clamping screw. The three larger models are suspended above the tank by means of vibratory absorbers. All the agitators can be regulated while in operation.

The small unit, working off a 220-v. single-phase 50-cycles A.C. supply, imparts to the medium in which the agitator stem and disc are inserted a vibration frequency of 6,000/min., at maximum amplitude of  $\frac{1}{4}$  in., with an acceleration of 14 g.

## New spot-welding process

To meet the need for speedy, flux-free spot-welding on stainless steels and also for tack welding on assembly work, the British Oxygen Co. has evolved the Argonarc spot-welding process. The process may be used also on bright mild steel and certain non-ferrous metals.

One of the major advantages of the process is that access to one side of the work only is required and this makes possible the use of the equipment on joints which would be inaccessible to conventional spot-welding equipment. A further advantage is the ability to join thin to thick sections.

The operating cycle is automatic and no skill is required of the operator apart from positioning the torch and working the trigger switch.

The equipment is fully transportable and, since the arc is screened by the torch nozzle, it may be used in any workshop without inconvenience to other personnel.

A descriptive leaflet is available and this includes information on the components comprising the equipment, its operation and details of typical joints for which the process is suited.

## 'Packaged' fire protection systems

Small plants in the U.S.A. are availing themselves of an economical built-in automatic fire protection system by purchasing a packaged automatic carbon-dioxide arrangement which can easily be installed by the plant's own workmen. The equipment, designed and made by the Walter Kidde Co. Inc., Belleville, New Jersey, is said to afford protection for normal industrial types of inflammable liquid hazards up to 6,000 cu. ft. The system can be adjusted to allow for protection against certain specific dangers.

It is claimed that by installing the new total-flooding 'standard Pak' system, moderate- and small-sized industrial plants can effect considerable savings over the cost of systems that have to be specially designed, fabricated and installed. The pre-engineered systems can be installed by the plant's own employees, thus saving both installation costs and special design costs for a particular system.

# World News

## GREAT BRITAIN

### Increased gas output

A total of 32 million cu. ft. of gas will be added to England's daily production by the expansion of three large gas works.

The first large gas works to be opened since nationalisation is at Howdon-on-Tyne, near Newcastle. Its production capacity is 12 million cu.ft./day of gas in addition to a daily production of 1,500 gal. of benzole, 5,000 gal. of tar and 6 tons of ammonium sulphate.

New gas-making and -compressing equipment is being installed at the North Western Gas Board's works at Partington, near Manchester, making the total capacity at Partington 25 million cu.ft./day, compared with 8 million cu. ft. three years ago. This will eventually be the largest gas-producing station in north-west England and the principal supply source of a gas grid system which will connect the industrial areas of Lancashire and Cheshire.

This new plant has a daily output of 5 million cu. ft. In addition, seven compressors, the largest installation of the kind in the country, are being erected. Each compressor will be capable of handling 500,000 cu. ft. of gas/hr. and will be driven by electricity generated by waste steam at the plant.

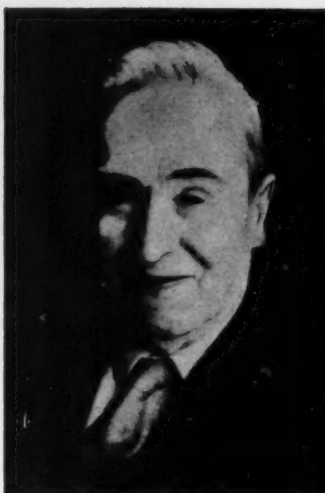
Coke ovens are expected to be constructed at Partington in 1953, at a cost of £5 million. They will have a daily production capacity of 15 million cu. ft. and will bring the plant's daily total production to 40 million cu. ft. A second coke oven of similar capacity to be installed later will raise the plant's total capacity to 55 million cu. ft. of gas daily.

### Appointments at Power-Gas and Ashmore's

The Power-Gas Corporation Ltd. and Ashmore, Benson, Pease & Co., Stockton-on-Tees, have recently made some interesting and important appointments which reflect the progressive policy of this large engineering firm.

Mr. C. E. Wrangham, C.B.E., B.A. (Cantab.), has been appointed a director on the main Board of Power-Gas. He is interested in several other companies and was a Principal Officer for Aircraft Equipment in the Ministry of Aircraft Production. He has paid a number of visits on governmental and commercial business to North and South America and possesses a wide experience in commercial and financial matters which will make his services of particular value in connection with the company's continually expanding activities and overseas business interests.

Mr. Charles Ingman, of Stockton, has been appointed a director on the Technical and Contracting Division of the Companies. He joined the firm in 1912



Mr. G. W. Riley.

and after spending some years in South Africa, worked his way through various departments of the organisation and in 1940 was appointed Contracts Manager. His experience and organising ability were tested to the full during the war years on such projects as the Mulberry Harbour and since then he has been responsible for many large-scale erection contracts in various parts of the country.

Mr. T. K. Hargreaves, D.S.O., M.A., A.M.I.Mech.E., the Works Manager, has been appointed a director of the Works Division of the Companies. Mr. Hargreaves joined the firm in 1936 and received practical training in the shops, drawing office and on erection of plant in various parts of Britain. He gave five years' service to the country during the war and was a Lieutenant-Colonel with the Royal Engineers during which time he was decorated with the D.S.O. After returning to the Company he was appointed Assistant Works Manager in 1947. Mr. Hargreaves spent two months in the U.S. studying American methods of production and played a major part in planning the new South Works which were opened in August, 1951, eight months after he had been appointed Works Manager.

Mr. C. Robson, who has been Director of Ashmore, Benson, Pease since 1944 and of Power-Gas since 1948, has also been Secretary of both Companies since 1939. He has now been relieved of the double burden he has carried by relinquishing his duties as Secretary. Mr. Robson, as Commercial Director, will be better able to devote his time to the constantly widening activities of the group for which purpose he has also joined the Board of an associate company, Rose-downs Holdings Ltd., Hull.

Mr. Laurence Davis, F.C.I.S., who has

been Assistant Secretary for five years, has been appointed Secretary in succession to Mr. Robson. Mr. Davis has been with the firm 23 years.

It is part of the policy of the firm to promote to high executive positions the members of their own staff who have proved ability and four of these appointments can thus be regarded as a reward for diligent and satisfactory service.

We offer to them all our congratulations.

### New director of Balfours

Mr. George William Riley, director of George Scott & Ernest Scott & Co. Ltd., has been appointed to the board of Henry Balfour & Co. Ltd. This is a very popular appointment, for few people have a wider knowledge of chemical engineering or have enjoyed longer consecutive service.

Mr. Riley joined George Scott & Co. Ltd. in 1899, while the firm was still in Christian Street, Whitechapel. He has witnessed the steady rise of Ernest Scott & Co. Ltd., the firm's great expansion during World War I and, finally, their amalgamation with Balfours, which took them to Leven, in Scotland. He was made a director of the Scott companies in 1936, and in 1946 celebrated his half-centenary with the firm.

### Retirements

Dr. C. J. T. Cronshaw retired from the board of Imperial Chemical Industries Ltd. on December 31, 1952, after 37 years' service with the company and its predecessors. He joined Levinstein Ltd. in 1915 and in 1924 became manager of British Dyestuffs Corporation Ltd., at Blackley. On the formation of I.C.I. in 1926 he became deputy chairman of the Dyestuffs Group delegate board, and from 1939 until his appointment to the I.C.I. board in 1943 was chairman of that delegate board. From January 1944 to September 1952 he was the Dyestuffs and Pharmaceuticals Group director, and in 1948 he was also appointed (jointly with the late Mr. H. O. Smith) to be personnel director of I.C.I.

Dr. Cronshaw will be succeeded as personnel director by Mr. R. A. Banks, who was appointed to the I.C.I. board on November 13, 1952. Mr. Banks was previously a managing director of the company's Alkali Division.

The chairman of Sharples Centrifuges Ltd., Mr. W. J. Murray, has retired. However, he will retain his seat on the board. His successor is the present managing director, Mr. A. H. Keable, M.I.Mech.E., M.I.Chem.E., who started the business in Britain in 1920 and has been managing director since 1928.

Mr. G. P. Balfour, B.Sc., A.C.G.I., A.M.I.Chem.E., will fill the vacancy created by Mr. Keable's promotion.

Mr. G. J. Keady, president of the Sharples Corporation, Philadelphia, has also joined the board of the British company.



Mr. C. K. F. Hague.

#### Babcock's managing director knighted

Among the awards in the New Year Honours was a knighthood for Mr. Charles Kenneth Felix Hague, M.I.Mech.E., M.I.E.E., deputy chairman and managing director of Babcock & Wilcox Ltd. He joined the firm in 1924 as combustion and operating engineer, and was appointed chief of the project department in 1928. He handled technical liaison and sales in New York from 1930 until 1934, when he was appointed general sales manager. He joined the board in 1940, being appointed deputy managing director in 1942, managing director in 1945 and deputy chairman in 1950. He is also deputy chairman of the Royal Ordnance Factories Board, and a director of several companies; was a member of the U.K. management/labour delegation to the U.S. in 1941 and is a member of the Engineering Advisory Council and of the Heavy Electrical Plant Consultative Council. He is also a Member of Council of the Institution of Mechanical Engineers, a Past President of the British Engineers Association and a member of the Management Board of the Engineering and Allied Employers National Federation.

#### Davey, Paxman appointment

Mr. G. W. Bone, M.A., works director of Davey, Paxman & Co. Ltd., was appointed assistant managing director of the company on January 1. He was educated at Oundle and Clare College, Cambridge, and took a first in the Mechanical Science Tripos in 1939. He gained his early workshop experience at Ruston's Lincoln works.

On leaving Cambridge he went to Rolls-Royce, Derby, and early in 1940 was commissioned with the R.A.F.V.R. After a period of general duties he spent some years with Air Commodore Whittle on the development of jet engines for aircraft.

He joined Davey, Paxman in July 1945 as chief experimental engineer, afterwards

becoming assistant works manager, which position he held until his appointment in December 1948 as works director.

#### Zinc control ends

On January 1, 1953, the provisions of the Copper, Lead and Zinc Distribution Order, 1951, ceased to apply to zinc. According to the Minister of Supply, the removal of this control means that licences will no longer be required for the purchase or sale of zinc; it arose from the decision already announced to reopen the London Metal Exchange on January 2, 1953.

Lead was decontrolled in October 1952. Licences will now only be required for the purchase of copper.

#### Aluminium contract ended

When the contract between the Ministry of Materials and the British Aluminium Co. expired at the end of 1952 it was decided to discontinue the arrangement under which the Ministry bought the company's output of virgin aluminium for resale along with imported metal. Most of the metal they produce will be used in the company's own works, but they have agreed to continue to supply to other users who require their metal for special purposes, and such sales will be licensed by the Ministry of Supply in accordance with any distribution scheme for the time being in operation. The company will sell at prices not exceeding the Ministry of Materials' current prices for imported aluminium. These arrangements will not affect the Ministry's selling price.

British Aluminium Co. production of virgin metal is about 30,000 tons p.a. Total U.K. consumption of virgin metal is about 200,000 tons p.a. Virgin aluminium is subject to allocation by the Ministry of Supply. British Aluminium Co.'s production and sales of the metal will be taken into account when imported metal is allocated.

#### Distribution of laboratory glassware

Baird & Tatlock (London) Ltd., W. B. Nicolson (Scientific Instruments) Ltd., Glasgow, and Messrs. W. & J. George & Becker Ltd., London and Birmingham, have been appointed additional distributors for laboratory glassware by Quickfit & Quartz Ltd.

#### Melchett medallist

Dr. Harold Hartley, C.B.E., chairman of Radiation Ltd., has been awarded the Melchett Medal for 1953 by the Council of the Institute of Fuel.

Besides serving as president of the Institution of Gas Engineers (1947-48), Dr. Hartley has been chairman of the Council of the British Cast Iron Research Association and, in 1945-47, president of that body. He is president of the Institute of Vitreous Enamellers and is also one of the D.S.I.R. visitors to the British Coal Utilisation Research Association. He has been a member of the Institute of Fuel since 1944 and was elected a fellow in 1948.



Mr. A. M. Hutcheson.

#### New director of Thompson Bros.

Mr. A. M. Hutcheson, A.M.I.Mech.E., has been appointed to the board of Thompson Brothers (Bilston) Ltd. He joined the firm in 1931 to develop the application of welded stainless steel products to chemical plant and, under his general guidance, the company has been very successful in the production of a large variety of plant.

#### Appointment by Howard Engineering

On January 1 Mr. Walter E. S. Toomey joined Howard Pneumatic Engineering Co., Ltd., Eastbourne, makers of rotary, centrifugal, proportioning and special pumps. His office is at 57-59 Victoria Street, London, S.W.1.

Mr. Toomey was formerly with Cannon (Holdings) Ltd.

#### New tar distillation plants for Coal Board

Two new tar distillation plants have been ordered by the National Coal Board. The first was ordered in the early part of 1952 by the N.C.B. East Midlands Division for construction at the new Avenue coke oven site near Chesterfield, and is the first complete new tar works to be built in Britain for many years. It will comprise a Wilton continuous tar distillation plant with an initial capacity of 200 tons/day, together with ancillary plant for hard pitch, tar acid concentration, naphthalene and anthracene production, blending for road tars and pitch creosotes.

More recently the N.C.B. South Western Division placed an order for a Wilton continuous distillation plant in connection with the tar works at Caerphilly. This plant will treat 150 tons/day of tar derived from new coke oven installations in South Wales. The plant incorporates up-to-date methods of pitch handling.

These contracts are among those recently received by Chemical Engineering Wiltons Ltd., a member company of the Simon Engineering Group.



## TURKEY

### President opens Unilever factory

A new Unilever factory in Turkey was officially opened on January 5 by the President of the Turkish Republic, Celal Bayar. The opening ceremony was attended by Dr. Paul Rykens, chairman of Unilever N.V., and Mr. Sidney J. van den Bergh, a member of the board of Unilever.

As far back as 1939 plans were considered to start local production in Turkey, but the outbreak of war prevented further developments. In 1950 negotiations with one of the biggest banks in Turkey were successfully concluded and a new company was formed, called the Unilever-Is Turk Ltd., Sirketi, in which Unilever N.V. took a share of 80% and the Is Bank 20%.

The recently completed factory comprises an oil mill, refinery, hardening plant and a margarine and edible fats manufacturing section. The oil mill capacity is approximately 12,000 tons of seed p.a.; the main raw material will be locally grown sunflower seed and the oil equivalent will be approximately 3,000 tons. The remainder of the oil requirements will be bought from local oil mills. The refinery has an output of approximately 6,000 tons p.a., and the hardening plant an output of 4,500 tons of hardened fat.

The products to be sold will be margarine, hardened fat, vegetable ghee and cooking oil. Margarine and vegetable ghee are virtually unknown in Turkey, although considerable quantities of a ghee product (Urfa, a melted butter) are consumed, but hardened fat is already an established product and approximately 4,500 tons are consumed annually.

The new factory is situated at Bakirkoy, near Istanbul. The board of the new company consists of three directors: Mr. J. J. Clerk (managing), Dr. K. Kac (marketing) and Mr. H. S. Roodhuyzen (technical).

### Germans to build sugar factories

A group of West German firms has now been given an order for the construction of two sugar factories in Turkey. The firms are headed by the Deutsche Bergwerke und Huettenbau GmbH., a subsidiary of the successor company of the former Reichswerke, in Salzgitter.

Total cost of the project is estimated at 32 million D.M. and the factories are expected to start operations on October 1, 1954.

## ITALY

### Fertiliser plant extended

An important new sector of the Montecatini factory at Novara, which manufactures nitrate fertilisers, has just entered into production. This factory is the first in Italy to use methane in the production of nitrate. It has an annual capacity of 35,000 metric tons of nitrates and will produce 45,000 metric tons of ammonium nitrate and 35,000 metric tons of am-

monium sulphate, as well as a large range of nitrate products for industrial use—the most important being urea.

Montecatini is about to start up another larger plant at Ferrara. This will be able to produce 50,000 metric tons of nitrate p.a., using methane as a fuel.

## SWEDEN

### Rubber from cellulose spirit

Scientists at the Technical College, Stockholm, have claimed the discovery of a means of producing rubber from cellulose spirit. The experiments, financed by the Swedish Spirit & Wine Co. and the State Research Council, have lasted about four years. They will be completed in the spring.

It is claimed that 3 kg. of cellulose spirit yield about 1 kg. of rubber. It is, however, more expensive than American synthetic rubber, because of the high cost of the raw materials in Sweden. The disadvantage of the Swedish synthetic rubber is said to be that it cracks easily when bent. However, it wears well. To obtain better results, natural rubber must be mixed with the synthetic material.

## NORWAY

### Rayon plant for north Norway

The first new industrial installation to be built in north Norway since the Government announced its development plan in 1951 will be a rayon weaving plant at Mosjoen. Machinery for this plant has arrived from the United States and it is hoped to start production in February. Yarn for the mill will come from the A/S Borregaard, whose primary concern is timber manufacture but who also operate various factories for the use of timber products.

The Development Fund established in 1951 by the Norwegian Parliament for establishing new industries in north Norway is now considering various other proposals. Resources placed at the disposal of the Fund total £10 million sterling.

### Norsk Hydro projects

Norsk Hydro has invested £20 million in new plant since the war. Installations now under construction will cost £6 million and future improvements an estimated £10 million. The production of heavy water is a lucrative source of income for Norsk Hydro. Norwegian, French, Swedish and British atomic piles use heavy water at the rate of 7 to 10 tons per pile, at £75,000 per ton. Output of magnesium metal in 1952 at Norsk Hydro reached 5,000 tons, with an estimated future increase to 10,000 tons p.a. World market price is now £250 per ton. As soon as possible, the firm will increase its production of complete fertiliser from 40,000 to 100,000 or 150,000 tons p.a. Among future plans is the production of potash from sea water. At present, potash has to be imported at a cost of about £1,500,000 p.a.

## FINLAND

### Chemical expansion urged

The Government-appointed Industrialisation Committee strongly recommends that chemical plants, especially those using the electrolytic method, be built in the valleys of the Oulujoki and Kemijoki rivers.

If these industries are established in the northern part of the country, large savings in operating costs will be possible, as only short power lines will be needed. Priority has been recommended for chlorine projects.

If power difficulties can be overcome, plants making calcium carbide and calcium cyanamide would be profitable. Increased capacity for calcium carbide would make possible domestic production of polyvinyl-chloride resins and other materials for the plastics industry.

## FRANCE

### No French alcohol for U.S.?

It is unlikely that France, one of the biggest alcohol producers in the world, will participate in the tender invited by the American Reconstruction Finance Corporation for 15 million gal. of alcohol, according to an official of the French Government's Alcohol Board.

Though the Board has the necessary stocks to supply the United States, the difference between international alcohol prices and the French alcohol price is too big to make a deal with France likely. The cost price of French alcohol is 85 francs/litre under the price-supporting policy of the French Government. Even if the Board cut the price by 50%, this would be too high, as alcohol made with Cuban molasses was sold at far cheaper prices, the official said. Unless the American Government is prepared to subsidise French alcohol imports there will be no French supplies, he added.

Some years ago, France shipped considerable quantities of alcohol to the United States at 47 francs/litre, but since then the international alcohol price has dropped to such an extent that no further exports have taken place.

## ISRAEL

### Mineral developments

Copper deposits in Israel are to be exploited through surface mining operations. They may yield 100,000 tons of ore during the next six months, according to the Chief Engineer of the Israel Mining Industries, an Israeli Government Corporation.

Further plans call for the extraction of an added 1,500,000 tons by open-pit methods, beginning in July. Copper ore reserves in excess of 40 million tons have been indicated by test borings at a site covering some 750 acres in the Nahal Timna area of the southern Negev.

The same company is exploiting phosphate and potash reserves and plans

extensive exploration of one deposit of manganese and two deposits of iron ore in Israel. Financing is being sought for planned production of some 1 million tons of phosphate ore and 300,000 tons of potash annually for export purposes. It is predicted that within five years Israel will be able to derive a gross income of \$24 million from the export of potash and phosphate.

#### YUGOSLAVIA

##### Manganese plant project

Work will begin this year on the construction of a manganese separator at the Zletovo mine in Macedonia, according to the Yugopress News Agency. The plant is scheduled for completion by 1954 and it will have a production capacity of 24,000 tons of manganese concentrate p.a. The plant will be the first of its type in Yugoslavia.

#### GREECE

##### Sugar and oil refineries

Initial plans for the installation of a sugar factory in Salonika by three Greek-American industrialists are progressing satisfactorily. It is estimated that the factory will produce 80,000 tons p.a. of sugar from sugar beet. In the first year, however, the majority of the production will derive from sugar cane imported from overseas.

The three industrialists mentioned also intend to install a petroleum refinery somewhere in the Athens-Piraeus area. No estimate has been made of the capacity of the refinery.

#### MALAYA

##### Bauxite mining resumed

Bauxite mining was resumed recently for the first time in the post-war period. Production was about 13,000 long tons in the third quarter of 1952. It is expected that further large-scale operations will get under way in the first part of the new year and greatly increase Malaya's bauxite production.

##### New cement plant

A new cement plant is under construction about 18 miles from Kuala Lumpur. Production is scheduled to begin soon at the rate of about 100,000 long tons p.a. This is expected to fill the needs of the Federation of Malaya as well as some of the Colony of Singapore.

##### New Unilever factory

Gen. Sir Gerald Templer, the High Commissioner and Commander-in-Chief of the Federation of Malaya, officially opened a new Unilever factory in Malaya on Saturday, December 20.

The factory is situated on the outskirts of Kuala Lumpur and will produce soaps and glycerin, edible oils, fats and margarine. The total output of finished products will be between 15,000 and 20,000 tons, utilising to the maximum raw materials indigenous to Malaya. Of these

### The Leonard Hill Technical Group

*Articles published in some of our associate journals in the Leonard Hill Technical Group this month include:*

**Manufacturing Chemist**—New Agricultural Fungicides; Mastitis and Teat Remedies; Sperm Oil and its Products; The Structure of Terpenes; Progress Reports on Detergents and Economic Poisons.

**Food Manufacture**—Progress in the Packaging Industry during 1952; Vitamin Progress in 1952; Progress in the Confectionery Industry, 1952; Measuring Temperature by Electronics.

**Petroleum**—Gasoline-Resistant Tank Coatings; The Oil Fields of Borneo; Industrial Petroleum Chromatography.

**World Crops**—Kenaf in Mauritius; Congo Jute and its Potentialities; Cultivation of Arid Zones; Drug Plant Cultivation in the Netherlands; Pest Control (Overseas).

**Fibres**—Chemical Structure of Fibres; Improved Process for Stripping Coloured Wool Waste; Loss of Oil during Processing in Jute Manufacture.

**Atomics**—The Scope of Radioactivation Analysis.

raw materials required, the Federation can supply probably 90% of the total in the form of palm oil and coconut oil.

A firm basis for local manufacture had already been laid by export trade over many years.

The operation of this new factory is expected to employ directly some 700 men and women, who will be Malaysians. Specialised training facilities will enable young Malaysians to advance to the senior administrative positions.

#### PAKISTAN

##### Natural gas discovered

In view of Pakistan's limited fuel resources, the discovery of natural gas at Sui may be of considerable economic significance. The reserves of natural gas are understood to be very substantial and, although they will not be utilised for the fertiliser factory to be built by a French firm, it is understood the Pakistan Industrial Development Corporation already have further plans for them, including the possibility of a second fertiliser factory to be erected at Kashmir, the nearest railroad to the source of the gas.

##### New paper mills project

The Pakistan Industrial Development Corporation has started construction work on a 30,000-ton paper mill in the Chittagong Hills Tracts, a 7,500-ton high-grade paper and board factory at Nowshera in the North-West Frontier Province, and a 7,500-ton straw-board factory in the Punjab.

All these projects are scheduled for completion by the end of 1954, at which time Pakistan expects to supply about 90% of its paper needs, except for newsprint.

Laboratory experiments are now in progress to determine the suitability of certain types of East Bengal woods for newsprint manufacture.

#### INDIA

##### Dye production expanded

India's sole dye producer, Atul Products Ltd., of Bulsar, is in future to produce azo, alizarine and sulphur dyes. The firm, which has gone into partnership with the American Cyanamid Co., of New York, has an authorised capital of 10 million rupees.

##### Sindri plant saves foreign exchange

The Sindri fertiliser factory enabled India to save 326 million rupees in foreign exchange (1 rupee = U.S. \$0.21) within its first year of operations in that country.

The saving was effected despite the fact that the factory has not yet reached its maximum capacity of 350,000 tons of ammonium sulphate annually.

The factory, which started operations in September 1951, utilises the gypsum process of making ammonium sulphate.

##### Sindri project

The Government of India is now conducting an engineering survey of the project for putting up a urea and ammonium nitrate plant in Sindri.

The extent of aid from the Technical Co-operation Administration will be settled after the results of the engineering survey are known.

##### Plans to expand steel industry

A delegation of Indian Government officials has been in the United States for discussions with the International Bank for Reconstruction and Development relating to expansion of India's steel industry. The group also explored the possibilities of interesting U.S. industrial and financial circles in establishing a new steel plant in India.

India's steel industry is said to be one of the basic industries accorded highest priority for immediate development. Expansion plans envisage a better than 50% increase by 1955-56 over the industry's present annual output of 1 million tons of steel and 1,800,000 tons of pig iron.

##### Starch from banana stems

A world patent has been taken out by the Council of Scientific and Industrial Research in New Delhi for the production of starch from banana stems. Varieties grown in Mysore State are said to have a high starch content. The Central Food Technological Research Institute at Mysore puts the average yield per banana stem at 1½ to 2 lb. of starch which can be used for edible and industrial purposes. The total acreage under banana cultivation in India is estimated at about 300,000.

##### Raw film project

A 20-million-rupee factory for the manufacture of raw films and other photographic

material is to be established in Mysore State in the near future. Sponsors of the plan state that, when the factory goes into full production, it will produce enough raw films to supply India's needs and there will be a surplus for export. Of the total capital of the plant of 20 million rupees, a substantial part will be made available by the Central Government and Mysore State Government.

The factory will be capable of manufacturing 400,000 sq. ft. of photographic paper per month within the first eight months of its going into operation. Ultimately the factory will produce 40 million sq. ft. of raw films of different types annually and 1 million sq. ft. of paper of different types p.a., in addition to other photographic materials.

#### Gas-from-sewage project

The Chief Minister of West Bengal and officials of the Calcutta City Office are considering the erection of a producer gas plant to generate 1.5 million cu. ft. of gas from city sewage. The plant would be built at Bantola in Dhappa, near Calcutta, at an estimated cost of 125,000 rupees. By utilising sewage gas it is estimated that the Government and the city could run 1,000 of their motor transport and conservancy trucks with a saving of 2 million rupees annually.

An alternative proposal for establishing small generating plants at various centres was also considered.

#### Caustic soda plant opened

A caustic soda plant has been opened in Travancore by Travancore-Cochin Chemicals Ltd. The factory is said to have a capacity of 20 tons of caustic soda daily. Production will go to India's rayon industry. The factory will also produce hydrochloric acid.

Travancore-Cochin Chemicals Ltd. was formed by the Travancore-Cochin Government, the Travancore Fertilisers & Chemicals Ltd. and the Mettur Chemical & Industrial Corporation Ltd. Investments in the company by the three participants were £300,000, £187,500 and £75,000 respectively.

The factory is expected to be producing at full capacity by mid-1953.

#### FORMOSA

##### New fertiliser plants

A plan to increase annual fertiliser production in Formosa from 138,000 metric tons to 438,000 tons calls for the establishment of two fertiliser plants, one in Keelung and another in Hualien. Output of the plants is scheduled at 176,000 tons of urea and 70,000 tons of ammonium nitrate, respectively.

In addition, the Kaohsiung ammonium sulphate plant is expanding its production from 7,000 to 60,000 tons.

The Taiwan Fertiliser Manufacturing Corporation produced 14,000 tons of fertiliser in August 1952, compared with 13,205 tons in July.

#### BURMA

##### Pulp and paper mill project

The Government of Burma is contemplating the establishment of a pulp and paper mill using bamboo as a raw material. The mill is to produce 70 tons daily of dried and baled bleached pulp and 30 tons daily of a general line of printing and writing papers for both domestic use and export.

It is understood that the Burmese Government recently accepted bids for the purpose of obtaining the services of a consulting engineer to design the proposed plant in accordance with basic requirements.

The project is reported to have high priority in Burma's industrial development programme, and actual construction is to be started as soon as possible.

#### JAMAICA

##### Alumina production

Production of alumina has begun in Jamaica. Initial production will be 120 tons/day, with expansion to 450 tons/day later. The plant, which processes ore to the stage of alumina before shipping, is operated by Alumina Jamaica Ltd., a subsidiary of the Aluminium Co. of Canada.

#### AUSTRALIA

##### New ammonia oxidation works

The Phosphate Co-operative Co. of Australia Ltd. has begun operating a new ammonia oxidation plant at its Geelong (Victoria) works. This will eliminate the use of nitre, formerly imported from South America, in the manufacture of superphosphate, it is stated.

#### CANADA

##### Synthetic vanilla plant

A new plant situated at Thorold, Ontario, has begun production of synthetic vanilla from waste sulphite pulp liquors. Owned by the Ontario Paper Co., the plant has cost \$1 million to build.

##### New instruments company

A company has been formed and has commenced operations in Toronto under the title of Kent-Norlantic Ltd. This organisation takes over from the parent company, George Kent Ltd., the responsibility of marketing throughout Canada Kent industrial instruments, certain other products and the Norlantic range of domestic and industrial water and steam meters. Arrangements are being made for the manufacture and assembly in Toronto of the Norlantic range and other products, and for stocks to be held to meet Canadian delivery requirements both of new equipment and spares. The company will operate a comprehensive organisation to cover after-sales service.

#### UNITED STATES

##### Cyanamid's new plant

A new plant to be built by the American Cyanamid Co. at New Orleans will produce ammonia, acetylene and hydrocyanic acid, from which acrylonitrile and ammonium sulphate will be made. The plant will cost about \$50 million to erect. The building of this plant will mean that for the first time Cyanamid will produce from raw materials instead of processed or manufactured ones. Proximity to natural gas, to process water from the Mississippi River, to good transportation facilities and to nearby markets in the textile and rubber fields led to the choice of the site.

Cyanamid have also bought a 1,600-acre plant site in Savannah, Georgia, for possible future use in the manufacture of dyes and pigments.

##### Coal pipeline proposed

Steel company experts at Youngstown, Ohio, are studying plans for 'piping' coal, just as they might pipe fuel oil, in an effort to overcome the competitive disadvantage with other steel centres which enjoy low-cost water transportation. The steel men have organised a new firm, Hydrocoal Transportation Co., to build a \$6 million to \$7,500,000 carrier extending 35 miles from East Liverpool. If built, such a pipeline might pare at least 50 cents/ton from freight rates for hauling coal to Youngstown.

##### New uranium recovery process

The U.S. Vanadium Co.'s mill at Uravan, Colorado, has been doubled in capacity, having installed a process specially developed for treating high-lime uranium ores. Because of this process, the difficulty and cost of extracting both uranium and vanadium from ores with a high lime content, which are fairly abundant in the Colorado Plateau area, can now be overcome.

This expansion of the mill has involved the erection of several 40,000-gal. thickening and solution tanks, new roasters, additional filtering equipment and enlargement of the sampling plant. The Uravan mill, with its new facilities, is now the largest uranium ore-treatment plant in the U.S. The Colorado Plateau contains the second largest source of uranium in the world, and more than \$30 million a year is being spent there for the mining and refining of uranium ores.

##### Petro-chemical research laboratory

Scientific investigations of the Celanese Corporation of America in the field of petrochemistry are now being carried on in a brand new ultra-modern research laboratory opened at Clarkwood, Texas, to supplant temporary buildings erected during World War 2.

The new office and laboratory building, operated by the research and development department of the company's Chemical Division, contains 21,000 sq. ft. of floor



space and houses 11 separate laboratories, 27 offices, a library, conference room, drafting room, duplicating room and lobby. The building is of brick and concrete, with all interior partitions of semi-glazed tile.

The Clarkwood operation, which is the centre of all the Celanese Corporation of America petrochemical research, is under the direction of Henry K. Dice. Achievements of the research group have been incorporated into manufacturing operations at the Bishop and Pampa, Texas, plants of the Celanese Corporation of America and at the Edmonton, Alberta, plant now being erected by the Canadian Chemical Co. Ltd., a Celanese affiliate. During the past year, as a result of work at Clarkwood, two new producing units were established at Bishop for the production of paraformaldehyde and trioxane.

#### More alcohol for synthetic rubber production

Increased demand for synthetic rubber has prompted the Reconstruction Finance Corporation to begin reopening its second alcohol butadiene plant. It is located at Louisville, Kentucky, and will be operated for the Government by Union Carbide & Carbon Co., which ran the plant for the R.F.C. before it was closed down last spring.

R.F.C. officials said it would take several months to get the plant back in operation. They estimated the move would mean an increase of 5,500 long tons monthly in the Government's overall synthetic rubber production.

#### New polyethylene waxes

New polyethylene waxes of low molecular weight are claimed to have an extremely wide range of applications in the manufacture of inks, polishes, paints and varnishes, and the textile industry. The products will be marketed by the Semet-Solvay Division of Allied Chemical and Dye Corporation, New York.

#### Naphthalene target raised

The Defence Production Administration has raised the capacity target for U.S. naphthalene plants to 564 million lb. by January 1, 1955. This is 9 million lb. more than the original figure set.

To meet the goal, capacity will have to be increased by 238 million lb. over January 1, 1951, instead of the originally estimated 204 million. D.P.A. said the new figure takes into account a reduction of 3 million lb. in estimated 1951 capacity, as well as 22 million lb. of capacity which can no longer be used because supplies of coal tar have ceased to be available.

British Resins Factory at Barry,' by T. W. M. Pond, 7.15 p.m., Gloucester Technical College. Joint meeting with R.I.C., S.C.I. and the Plastics Institute.

February 25. 'Some Aspects of the Chemistry of Butenolides,' by Prof. Wesley Cocker, 7.45 p.m., Chemistry Department, Trinity College, Dublin.

February 26. 'Some Applications of the Separation of Large Molecules and Colloidal Particles,' by Prof. A. Tiselius, 7.30 p.m., Lecture Theatre, The Royal Institution, Albemarle Street, London, W.1.

February 26. 'Recent Studies Relating to Hydrocarbon Oxidation,' by Prof. A. R. Ubbelohde, 5 p.m., Chemistry Lecture Theatre, The University, Liverpool. Joint meeting with R.I.C., S.C.I. and the British Association of Chemists.

February 26. 'Electrode Kinetics,' by Dr. J. O'M. Bockris, 7.30 p.m., Chemistry Lecture Theatre, The University, Sheffield.

February 27. 'Physical Chemistry of Acetaldehyde and some of its Reactions,' by R. P. Bell, 5 p.m., Washington Singer Laboratories, Prince of Wales Road, Exeter.

March 3. 'The Non-steady State in Chemical Kinetics,' by Prof. H. W. Melville, 6.30 p.m., Department of Chemistry, The University, Leeds.

March 3. 'Molecular Vibrations and Chemical Problems,' by Dr. H. W. Thompson, 5 p.m., University College, Leicester.

## MEETINGS

#### Institution of Chemical Engineers

February 10. 'Heat Transfer from Luminous Gas Flames in Vertical Tubes,' by S. R. Tailby and Muhammed Aly Saleh, 5.30 p.m., Geological Society, Burlington House, Piccadilly, London, W.1.

March 7. 'The Effect of Packing Size on the Absorption of Carbon Dioxide from Air with Caustic Soda Solutions,' by K. Greenwood and M. Pearce, 3 p.m., College of Technology, Manchester.

#### Chemical Society

February 11. 'Selective Herbicides and the Principles of Selective Toxicity,' by Prof. G. E. Blackman, 7.30 p.m., Robert Gordon's Technical College, Aberdeen. Joint meeting with the R.I.C. and S.C.I.

February 12. 'The Protein Requirements of the Ruminant Animal,' by Dr. R. L. M. Syngé, 5.45 p.m., Department of Chemistry, University College of North Wales, Bangor. Joint meeting with Liverpool Section, S.C.I.

February 13. Bedson Club lecture. 'The Molecular-orbital Theory of Organic Chemistry,' by Prof. M. J. S. Dewar, 5.30 p.m., Chemistry Building, King's College, Newcastle-upon-Tyne.

February 13. 'Colouring Matters of Dragon's Blood Resin and Related Topics,' by Prof. A. Robertson, 5.15 p.m., Chemistry Department, United College, St. Andrews.

February 13. 'The Synthesis of Sugar,' by Dr. J. K. N. Jones, 5 p.m., New Chemistry Building, The University, Southampton.

February 16. 'Chromatography in the Study of Amino-acid Metabolism,' by Dr. C. E. Dent, 7 p.m., Department of Chemistry, The University, Leeds. Royal Institute of Chemistry lecture.

February 16. 'The Work of the British Coal Utilisation Research Association,' by Dr. D. T. A. Townend, 7.15 p.m., Department of Agriculture Lecture Theatre, Queen's University, Belfast. Joint meeting with R.I.C. and S.C.I.

February 16. 'Physical Chemistry of Some Reactions of Acetaldehyde,' by R. P. Bell, 5.30 p.m., Chemistry Department, University College, Cardiff.

February 19. 'The Fertiliser, Phosphorus, and Allied Industries,' by Dr. B. Raistrick, 7.30 p.m., North British Station Hotel, Edinburgh. Joint meeting with R.I.C. and S.C.I.

February 20. Annual General Meeting followed by 'Allene Chemistry,' by Prof. E. R. H. Jones, 7 p.m., The University, Glasgow.

February 20. 'The Significance of Kékulé Structures on the Stability of Aromatic Hydrocarbons,' by Dr. Eric Clar, 7 p.m., Chemistry Department, University College, Dundee.

February 25. 'Construction of the

#### Royal Institute of Chemistry

February 13. 'Some Aspects of the Physical Chemistry of Plasma Substitutes,' by Dr. H. Campbell, 6.30 p.m., Brighton Technical College, Brighton.

February 13. Lecture on 'Chemotherapy,' 6.30 p.m., Brighton Technical College, Brighton.

February 18. Discussion on 'Education in Chemistry,' 6.30 p.m., Wellcome Research Institution, 183 Euston Road, London, N.W.1. Joint meeting with British Association of Chemists.

February 20. 'Some Aspects of the Chemistry and Stereochemistry of Polycyclic Aromatic Hydrocarbons,' by Prof. J. W. Cook, 8.15 p.m., University Zoology Lecture Theatre, Reading.

February 25. Lecture on 'Atomic Science,' by A. G. Maddock, 6.30 p.m., Norwood Technical College, Knight's Hill, London, S.E.27.

#### Institute of Metals

February 16. 'The Constitution and Properties of Some Titanium-Base Alloys,' by W. A. Baker, 7.30 p.m., The University, St. George's Square, Sheffield.

February 18. 'Metallurgical Aspects of Lubricating Problems,' by A. L. H. Perry, 6.30 p.m., Engineers' Club, Albert Square, Manchester.

March 5. 'Lubrication in Cold-Working Processes,' by A. E. McAulay, 7.15 p.m., Chemistry Department, The University, Leeds, 2.

### Society of Chemical Industry

February 26. 'The Physics and Chemistry of Detergent Solutions,' by Dr. K. G. A. Pankhurst, 7 p.m., South East Essex Technical College, Longbridge Road, Dagenham, Essex. Joint meeting with R.I.C.

March 2. Symposium on 'Production and Utilisation of Petroleum Raw Materials in the U.K. Chemical Industry,' 10 a.m., Institution of Electrical Engineers, Savoy Place, London, W.C.2. Joint meeting with Institute of Petroleum.

### Chemical Engineering Group

February 18. 'Practical Aspects of Modern Trends in Coating Protection of Buried and Submerged Structures,' by H. Footner and K. A. Spencer, 6 p.m., Stephenson Building of Durham University, Newcastle.

February 24. 'Synthetic Resin Cements used in Chemical Engineering Practice,' by E. K. Earp, S. Shapiro and A. E. Wiggs; 'Corrosion-Resisting Properties of Some Synthetic Resin Cements,' by V. Evans, 6.30 p.m., Chemical Society, Burlington House, Piccadilly, London, W.1. Joint meeting with Plastics Group.

### Crop Protection Panel

February 16. 'Physical Factors in Relation to Biological Activity of Insecticides,' 5.30 p.m., Chemical Society, Burlington House, Piccadilly, London, W.1.

### Road and Building Materials Group

February 19. 'The Stability of Asphalt Mixtures as Affected by Aggregate Size,' by Dr. B. H. Knight, 6 p.m., The Building Centre, Store Street, Tottenham Court Road, London, W.C.1.

### Institute of Refrigeration

February 17. Discussion on 'Novel Refrigeration Cycles,' 5.30 p.m., The Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1. Joint meeting with Low Temperature Group, Physical Society.

### Institution of Works Managers

February 12. 'Engineering for manufacture,' by A. J. Cowderoy (S. Smith and Sons (England) Ltd.), 12.30 p.m., The Plough, Kenton Road, Kenton, Middlesex.

### Hull Association of Engineers

February 18. 'The Gas Turbine in Industry,' by J. R. Needham, 7.30 p.m., Royal Station Hotel, Kingston-upon-Hull. Joint lecture with the Yorkshire Branch, Institute of Mechanical Engineers.

### Hull Chemical and Engineering Society

February 24. 'Some Chemical Aspects of Motor Car Manufacture,' by H. R. Mason, 7.30 p.m., Church Institute, Kingston-upon-Hull.

### Incorporated Plant Engineers

February 9. 'The Manufacture of Plate Glass' and other films, by Pilkington Bros. Ltd., 7.30 p.m., Mathers Hotel, Dundee.

February 10. 'Instrumentation and Automatic Control for Medium and Small Boilers,' by Mr. Klepp (Elliott Bros. (London) Ltd.), 7.15 p.m., Engineers' Club, Albert Square, Manchester.

February 11. 'An Approach to Maintenance—the Report of the U.K. Specialist Team on Plant Maintenance,' by H. G. Hilton, 7 p.m., Welbeck Hotel, Nottingham.

February 17. 'Heat Transfer,' by R. A. Brecknell, 7 p.m., Engineering Centre, 351 Sauchiehall Street, Glasgow.

February 18. 'Steam-Flow Measurement and its Relation to Thermal Efficiency,' by W. M. Barber, 7.15 p.m., Grand Hotel, Bristol.

February 18. 'Safety and the Factory Acts—Aspects Affecting the Plant Engineer,' by H.M. Inspector of Factories, 7 p.m., Bull Hotel, Rochester, Kent.

February 23. W. A. Wordley, Plant Engineer to the Bradford Dyers' Association, on his recent visit to America as a member of the Fuel Conservation Team, 7.30 p.m., Leeds University, Leeds.

### Institute of Fuel

February 17. 'Refractories—with particular reference to Hot-face Insulation,' by Dr. J. White, 6 p.m., James Watt Institute, Great Charles Street, Birmingham, 3.

February 18. 'Methane at Point of Ayr Colliery,' by S. J. Young, 7.30 p.m., Grosvenor Hotel, Chester. Joint meeting with Stanlow Branch, Institute of Petroleum.

### Institute of Metal Finishing

February 12. 'The Electrodeposition of Tin and its Alloys,' by J. W. Cuthbertson, 7.30 p.m., Engineers' Club, Albert Square, Manchester.

## Rates of Drying

(Concluded from page 51)

and there is very little advantage to be gained from using a relatively expensive rotary drier.

In conclusion it must be said that there is a very noticeable lack of published comprehensive data necessary for a wide discussion of drying processes, and industry itself has confirmed the need for such information. The first step required is a general classification of the drying characteristics of a wide range of materials. Even so, each drying problem must be considered on its own merits.

### REFERENCES

- <sup>1</sup>W. B. Van Arsdel, *Trans. Am. Inst. Chem. Engrs.*, 1947, **43**, 13.
- <sup>2</sup>A. Fick, *Ann. Physik.*, 1855, **94**, 59.
- <sup>3</sup>S. J. Friedman and W. R. Marshall, *Chem. Eng. Prog.*, 1949, **45**, 482 and 573.
- <sup>4</sup>D. W. Van Krevelin and P. J. Hoftijzer, *J. Soc. Chem. Ind.*, 1949, **68**, 91.
- <sup>5</sup>J. H. Perry, *Chemical Eng. Handbook*, 3rd Edition, 1950, Section 13.
- <sup>6</sup>C. F. Prutton, C. O. Miller and W. H. Schuette, *Trans. Am. Inst. Chem. Engrs.*, 1942, **38**.
- <sup>7</sup>Walker, Lewis, McAdams and Gilliland, 'Principles of Chem. Eng., 1937,' 3rd Edition, 1950, Section 13.

**Humidity control.** Uncontrolled humidity is a problem in many manufacturing processes and three recent Birlec publications (Nos. 82, 83 and 84) outline how three aspects of this problem can be solved. Leaflet No. 82, 'Birlec Lectrodryer Moisture Adsorbers,' deals with standardised equipment for removing moisture and moisture vapour from compressed air and other gases. A different design of Birlec Lectrodryer is described in leaflet No. 83; these 'CH' units are principally used for maintaining low humidities in process, storage and other rooms, in such industries as food processing, pharmaceutical manufacturing and electrical engineering. Ancillary to the Lectrodryer, is often installed the Birlec Lectrofilter, which is described in leaflet No. 84. These units are of particular importance when drying compressed air, as oil in droplet or vapour form is often carried over from the compressor to the supply line.

## CHEMICAL & PROCESS ENGINEERING ENQUIRY BUREAU

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